Summer 1961 $2.00

TECHNOLOGY and CULTURE

The International Quarterly of the Society for the History of Technology

Technology as Cause in History

ROGER BURLINGAME
on Technology: Neglected Clue to History

LEWIS MUMFORD
on History: Neglected Clue to Technology

H. STUART HUGHES'
Commentary: Technology and the History of Ideas

Published by the
WAYNE STATE UNIVERSITY PRESS
for the
SOCIETY FOR THE HISTORY OF TECHNOLOGY

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Published quarterly in Winter, Spring, Summer, and Fall by Wayne State University Press, Detroit 2, Michigan

Publication of this journal has been made possible by a grant from the Wilkie Brothers Foundation, Des Plaines, Illinois.

Editorial Office: The Society for the History of Technology, Case Institute of Technology, Cleveland 6, Ohio.

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TECHNOLOGY and CULTURE

volume II, no. 3 · summer 1961

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*Technology as Cause in History**

TECHNOLOGY: NEGLECTED CLUE TO HISTORICAL CHANGE

ROGER BURLINGAME†

YEARS AGO WHEN I started to write some books on those cultural aspects of history that deeply interested me, I thought of myself as a sort of bridge between professional historians and that part of the lay public that could never quite understand what the academic historians were saying. The reason I wanted to act in this capacity was that I was a member of that benighted public myself, and it seemed to me then that historians were writing for other historians with the incidental intent of imposing their product on captive audiences of profoundly puzzled students. In college I was as bewildered as anyone—probably more so—and when I got out and my education began, I felt a gnawing hunger for what I had missed, and this provoked me into trying to understand why.

Looking back at the books I had read, it seemed to me, in my mood of experimental writing, that they were almost wholly abstract. They were as hard to grasp, though for different reasons, perhaps, as abstract paintings. In them, events were presented *in vacuo*. They had evolved from theories rather than from other events or as a result of concrete causes. Thus, until students had become scholars and accustomed to theoretical thinking, they thought of the discipline of history as a memory contest. It was discipline indeed.

* These papers were presented at a joint program of the Society for the History of Technology and the American Historical Association in New York City on Dec. 28, 1960. Dr. Mervin J. Kelly, retired President of the Bell Telephone Laboratories, presided over this session.

† Roger Burlingame is the author of a trilogy on the development of American technology: *March of the Iron Men, Engines of Democracy, Backgrounds of Power* (New York, 1938, 1940, 1949).

The books gave much space to wars but little, if any, to weapons or munitions or food supply or what the military engineers did for the movement of armies over rugged terrain: the concretions, in short, of war, and the factors that, over the years, altered its aspect. The books were concerned with economic theories but not with the technical means of production. They had much to say about urban trends—the movement of populations into cities—but they omitted such vulgarities as water supply, sanitation, paving, lighting, urban architecture, and building. To the reader the cities existed on a map, not on land. And wars, explorations, migrations were also on maps or calendars; never on mountainous earth or stormy sea.

There was no sense, then, of reality in the reader's mind. Instead he was asked to jump across the spaces filled with the familiar, earthy aspects of life to the abstract peaks of Renaissance, Reformation, Restoration, Enlightenment, Awakening, or whatever artificial designations suited the historians' convenience.

That my view was not unique is shown by George Sarton, who complained about a similar neglect he had found in his reading of history:

> It may seem strange that this technical basis of the Renaissance has been constantly overlooked, but that is simply due to the fact that our historians are literary people, having no interest whatever in craftsmanship. Even in art it is the idea and the ultimate result, not the process and the technique which engross their attention. Many of them look upon any kind of handicraft as something menial. Of course, this narrow view makes it impossible to grasp the essential unity of thought and technique, or of science and art. The scope of abstract thinking is very limited; if it be not constantly rejuvenated by contact with nature our mind soon turns in a circle and works in a vacuum.[1]

You will observe that I have spoken so far in the past tense. This is because I know that reform is on the way. Certain professors, provoked, perhaps, by the radical writings of amateurs, have looked outside the shadow of the academy and found, out there, a hungry public to whom unknown facts could be told only in terms of known ones. Thus, in their research and in their writing, they have come to integrate events with technics and the arts, to introduce familiar artifacts into the empty niches of their

historiography, and, in short, to bring their story down to the earth we know. In the composition of textbooks this is especially true on the pre-college level.

Surely, this sort of presentation is drawing students out of their apathy, making them eager to pursue a subject that is no longer a "discipline" or a memory contest, but rather a story of the past that has come alive in a world of technological miracle, that is comprehensible even in the absorbing ambiance of contemporary science. Here, I am the first to admit that that ambiance is too absorbing—dangerously so, indeed—but for that very reason, the influx of the human currents, introduced by the historian who sees both things and men in their normal relations, will produce a balance of values.

The aim of the Society for the History of Technology is best conveyed, I think, by the title of its journal, *Technology and Culture*. From its start the society has encouraged and supported the new integrated history; its publications have, in general, avoided the presentation of technological events as if they hung in a vacuum, nor have they emphasized to the point of unbalance, the part played by technics in the story of civilization. That too is my effort in this search for neglected technological clues to historical change. And I wish emphatically to dispel any suspicion caused by the wording of the titles of our articles that Mr. Mumford and I are firmly seated on opposite sides of a fence; I am more inclined to share his views than to dispute them. Far from being mutually exclusive, our topics are complementary. Both suggest challenge and criticism because both are concerned with delinquencies, and the exposure of these should make a dent on any complacency we may have.

Certainly in early phases of the march toward civilization, technical development had to await changes in social history before it could become useful to society. Although there have been sporadic inventions of labor-saving devices, for example, ever since men first lived in communal association, many were without material consequence in a society whose economy was based on slave labor. A conspicuous example is Hero's steam turbine which remained a toy or a magician's trick as long as slaves—the currency of war—had to be maintained and exercised. In modern history, many of the inventions of Leonardo da Vinci not only were superfluous

amid an abundance of cheap manual labor but must also await, for their consummation, further advance in collateral technics. Yet whether the technological change came as a result of social change or vice-versa may be a hen-or-egg question. Whitehead, for example, believed that "the growth of technology is the greatest among the causes which weakened the necessity for slavery."[2] Perhaps we should say that the two changes went hand in hand. Certainly, there must have been an awareness in societies about to graduate from a slave or cheap labor economy of the existence of a technological potential. Had it not been there, it is obvious that the social change would have been long delayed.

A neglected clue to technological changes which, in turn, produced historical ones is the religious impulse. In a remote pre-Christian era, the construction of tombs and temples developed techniques of architecture and engineering whose magnitude still puzzles students of those subjects. There is, of course, a large body of literature on this topic but it is contained in technical volumes based on archaeology. Only occasionally may the fascinating physical details be found in treatments of a culture as a whole. With a few such conspicuous exceptions as James Henry Breasted, general historians of ancient cultures have been more concerned with theologies than with the ponderable effects of religious preoccupation, with dynasties or mass migrations than with the basic means of communal activity. In medieval history we find the details of cathedral construction which for centuries occupied the minds and determined the lives of almost entire urban populations lost among pages of abstractions about the Church.

In this interplay of religion, technology, and social history, a neglected story is that of the measurement of time. In Egypt, star-gazing priests, observing that the annual coincidental rising of the sun and Sirius was simultaneous with the annual flooding of the Nile, began the establishment of the calendar and thence a program for the beginning of agriculture in the river valley. The further priestly observations of sun, moon, and stars provided the division into seasons, months, and days so essential to planting, harvesting, and husbandry. It was the priests, too, who drew on the desert sands the semicircle of the shadow clock which marked the diurnal movement of the sun and, later, provided the arbitrary division of the semicircle into hours—a first step in taking time

measurement out of the hands of God and putting it into the hands of man.

Except in special kinds of history, that first automatic machine, the clock, has been largely neglected. Yet, together with the calendar it has become a *sine qua non* of history itself. From its beginnings in the sun dial, the water clock, and the fire clock, it was the first instrument of orderly discipline in both communal worship and civic organization. Lewis Mumford has told of its early use in European monasteries to mark the canonical hours.[3] With the mechanical clock, the final step in the removal of time measurement from divine control, the hours and minutes moved out of the domain of the church and began the tyranny under which we work today.

Under the clock's increasingly dominating aegis the march of society proceeded toward the industrial age. Despite all the animistic devices with which clockmakers tried to keep it within the circle of human thought, it acquired a peculiarly impersonal character. It gave the boss who replaced the slave-driver unprecedented power, for he could refer to its relentless motion as beyond his own control. The chains it forged for the worker were tougher, more unbreakable than those which bound the galley oarsman to his seat. Never in history has man surrendered himself more completely to a machine. Yet once he recognized its power and developed other social and technical inventions to balance it, the clock gave him new freedom by helping him to budget his hours and plan his recesses.

In addition to causing prodigious changes in economic, political, and social history, the technology of the mechanical clock had a direct effect on every department of mechanical technology. Its design and construction demanded the first accurate machine tools. Into the shops of the clockmakers came the first screw-cutting lathes, the first slide-rests, the first gear-cutting devices. The clock's wheel train established the principle of gear ratios; its pendulum and escapement the performance of rhythmic control. Clock and watchmakers were the first to understand the production and use of interchangeable parts. As I wrote in my book *Bockgrounds of Power*, " Virtually every phase of modern mechanism has the clock or a clockmaker's ingenuity somewhere in its

ancestry."[4] Yet how many pages of general history are devoted to this technic and its evolution?

Historians are more generous in the space they give to the printing press—perhaps because of its literary implications. They give it credit for breaking the power of the medieval church and thus advancing the Reformation, for its influence in the spread of education, and for its promotion of discovery, exploration, and settlement. But usually they treat printing as an abstraction, saying little about the revolutionary aspects of the specific inventions which brought it out of its long background of oriental block printing: the casting of individual movable metal types in moulds so exactly that they were interchangeable and could be locked in lines—details which for the first time made quantity printing effective, and thus an instrument of historical change. Nor do they often tell the romantic story of the invention of paper, which, after its long journey from East to West, came into the hands of Gutenberg and made the use of his press possible.

Despite the many remarkable technics that we find in western civilization through the seventeenth century, we can point to few which caused radical historical change. In addition to those I have mentioned, there were, of course, the instruments of navigation, the many ship inventions, the engineering technics of road, bridge, tunnel, and canal construction, and the improvements in artillery and other weapons of war. Others had, however, an immense effect upon the growth of technology itself and upon the advances in what was called pure science. The animistic automata that captured the public fancy in the 1600's were evidences of the growing mechanical skills that were later to be used in the constructions of productive automatic machines. Extensive use of water-wheels and wind-mills for milling and for pumping induced thoughts about prime movers which would later replace manpower. The telescope and microscope, both in use during the seventeenth century, were of great importance to the Newtonian revolution in science.

It was not, however, until the eighteenth century that technology—and here the semanticists will forgive me—began to run away with history. This got under way at about the time of the Industrial Revolution in England. I am afraid that in using that convenient term, I shall incur the displeasure of Doctor Mumford,

who has great contempt for it; yet it seems to me, granting that all classifications are artificial, as exact as most historical milestones, and I am sure that any designation I may use will have been put in the doghouse by someone. I should like to make myself clear, however, by stating that I do not consider this eighteenth century upheaval a technological revolution nor do I believe that it stemmed from the steam engine or the mining of coal and iron, but rather from that combination of technics which comprised the factory system. I believe, too, with Sarton and Thorndike, who have risked opprobrium by using the term, that it was mainly an economic or social revolution rather than a technological one. This, too, is the view of Thomas S. Ashton, Emeritus Professor of Economic History, University of London, who writes: "The phrase 'Industrial Revolution' has been used by a long line of historians and has become so firmly imbedded in common speech that it would be pedantic to offer a substitute."[5] So, until a better tag is devised, I shall go along with these writers.

The "dark Satanic mills," which revisionists are now maintaining were not so dark after all, produced laws as well as textiles. The trials of the women and children who worked under the tyranny of the relentlessly turning spindles, but especially under the tyranny of the clock, were aired before parliaments until a pattern of humanitarian legislation evolved. This, in parallel with more and more productive technics, has continued to the present time, at which even the clock and the calendar seem to have been subjugated. The observations of Engels on the aftermath of the English Industrial Revolution, when conveyed to Karl Marx, gave rise to the Communist Manifesto, a declaration whose consequences are still with us.

The economic effects of the industrial complex have not been neglected by historians of the nineteenth century. The new abstractions of capital and labor and *laissez-faire*, along with that of the rise of the bourgeoisie, have provided abundant means of escape from technological details. Yet the operation of the mines; the steady improvement in the use of steam for transport on land and sea; the new application of the laws of thermodynamics to the engines of Boulton and Watt, which insured their commercial use; the improvements in the ships of the British navy which maintained the Pax Britannica; the remarkable machine sequences de-

veloped in the workshops of Maudslay, Brunel, Wilkinson, Roberts, Clement, and Bramah that not only supplied equipment for these ships but made a lasting contribution to the practice of quantity production—a practice that later had such sweeping social effects, especially in America; the fabulous Wedgwood potteries in which long strides were made toward the improvement of labor conditions; and the changes brought about in social geography by railway inventions of locomotive, track, and signalling—these are some of the things which the new historians must integrate into the story of the era.

But we must cross the Atlantic to discover the most radical effects of technology upon historical change. The United States, of course, was naturally subject to accelerating change, as any land must be whose periphery only has been settled—and that by energetic and dynamic people. Here the changes were so rapid—once a certain inertia due to many causes had been overcome—that this country became the scarcely credible wonder of an elder world.

Perhaps it was because of this speed that the neglects of which we are speaking are more numerous in our history than in that of any other people. These were not merely neglects of technological clues but of almost everything else which historical record should rightly contain. With the characteristic American love of abstractions and generalities, most of the earlier American historians moved in an ethereal realm of star-spangled patriotism or in the atmosphere generated by the illusory sense of "manifest destiny."

In recent years all this has provided a field day for the revisionists. Much good has come from the researches of these eager reformers in the discovery of neglected phases, though occasionally they seem to be playing the game of "revision for revision's sake" and enjoy reversing long-accepted theses simply because they have been accepted. To scholars who engage in such sport, anything that makes sense, such as Frederick Turner's emphasis on the part played by the frontier in American history, comes under suspicion. Yet in a true appraisal of the effects of technology upon change in the social, political, and economic pattern of the United States, I contend that we must accept the thesis that American technics were special and sometimes unique precisely because they were so largely essential to the movement of that frontier.

As we look back on the continental conquest, we are struck by the fact that in spite of the movement of the people over such vast spaces, the United States never lost its national integrity. Why did the migrations not result in the formation of half a dozen or more separate and perhaps hostile nations? Our historians have answered this question giving credit to the wisdom of the Founding Fathers in the drafting of a constitution which created a balance of power between state and federal governments; to the federal control of the public domain; to such organizing statutes as the Northwest Ordinance; to policies of land grants, homestead acts, and so on. The part played by peculiarly American technics, however, has been largely neglected or, at best, described without reference to their peculiarities.

The technology behind the frontier which pursued the advance and kept front and rear from getting too widely separated was makeshift and extremely wasteful; it was generally unscientific and founded almost entirely upon inventions borrowed from older societies and adapted by the celebrated Yankee ingenuity. But its very wastefulness gave it speed, and once it was able to exploit the abundant natural resources of the continent, nothing could stop its advance across or around the empty spaces.

The wood-burning steamboats working against the currents in the rivers achieved the settlement of the river towns and maintained the intercourse between them. The canals, built by rule-of-thumb engineering, the railway road-beds with ties embedded in loose gravel, the iron T-rails, all the light construction adapted to light wood-burning locomotives mounted on swivel trucks to get them round sharp curves—these were all instrumental in the transportation of goods and persons between the rivers. Eventually the spaces left empty by river and railroad traffic were filled when the cheap, mass-produced car, a uniquely American technic, established a new set of frontiers. Meanwhile the fast clipper ships sailing round the Horn had advanced the settlement of the Pacific Coast, and the technics employed in the Nevada mines had drawn many of these settlers eastward toward a meeting with the westward migration, a movement brought to its consummation by the transcontinental railroads. We may imagine how the map of the country would look if these factors had been lacking. Furthermore, without the reckless speed of their operation, the nation might

well have fallen apart through long interruption of communication. To Abraham Lincoln, the connection between technology and union was inescapable. "That portion of the earth's surface," he wrote, "which is owned and inhabited by the people of the United States is well adapted to be the home of one national family, and it is not well adapted for two or more. Its vast extent and its variety of climate and productions are of advantage in this age for one people, whatever they may have been in former ages. Steam, telegraphs and intelligence have brought these to be an advantageous combination for one united people."[6]

An invention which is generally recognized by historians of the post-Civil War period as affecting both economic and social history is Eli Whitney's cotton gin, which, because it brought an increase in slavery, is named as a cause of the war. These same historians, however, ignored, until very recently, Whitney's part in the establishment of the interchangeable parts system. Although certain revisionists are now contending that this was all a myth and that Whitney was an imposter, they can scarcely deny that North, Colt, Root, McCormick, Singer, Pope, Olds, and Ford carried this American system into quantity and then mass production of machines. Yet few pages in our history books are dedicated to these factors in the progress of American industrial leadership, and even fewer deal with mass production as a contributing cause in the realization of the equality concept by making luxuries available to the masses.

A few writers have seen the sewing machine as advancing the cause of the emancipation of women and the feminist movement. Lately, too, the role of this practical technic in mass warfare through the rapid manufacture of soldiers' uniforms and shoes has been accorded space in general histories. Pioneers in the new history have emphasized the part such technics as the McCormick reaper played in turning the Civil War into a war of attrition. Nothing will be served by adding further to the list of these technological clues to historical change in America.

Today we are becoming increasingly conscious of the role of technology in our lives. That new means of communication, especially when they are under the pressure of the advertising fraternity, produce conformity of opinion and mediocrity of thought is a well-worn theme of current fiction and drama. The

effect of television on politics is a subject of much discussion at the moment. It is perhaps too soon to estimate the effect of automation on technological employment, but some economists are already trying it. As for the atomic and hydrogen bombs, they have brought what the late Mr. Dulles called "agonizing reappraisals" throughout the world.

It is true that much thought is given in the course of our daily activity to the technological phenomena with which we are surrounded. But the trouble is that we envision these so-called miracles as isolated, as having come into being by some sort of push-button impulse, as if they had no historical background. That is why it is more and more the duty of historians to show that they have evolved through centuries of patient work, of both trial-and-error and scientific method, of repeated heart-breaking failure, of long intervals between the pure and the applied science, of the passage of time between technical and social invention; and, above all, it is necessary to show that machines and processes were made by man for man and never have had or ever will have powers divorced from his.

That, at any rate, is the view of this lay writer who is without academic training either as a technician or as a historian but who has a strong hunch that technology and culture have become inseparable.

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HISTORY: NEGLECTED CLUE TO TECHNOLOGICAL CHANGE

LEWIS MUMFORD*

THIS PAPER IS MEANT mainly as an admonition and a challenge to the new historians of technology; and it has partly been prompted by the serious lapses and omissions in the five-volume *History of Technology* that was recently completed. Yet there is a sense in which this challenge is slightly premature, and even the editors and contributors to that history deserve our charity, if not our complete absolution, for concentrating upon the internal history of technology and largely neglecting the larger historical situation. For the fact is that the primary data of technological history have not been collected and assorted on a sufficient scale; and a vast amount of documentary work, which should have been done in the nineteenth century, if not earlier, still remains to be done before technological processes and events can be fully understood in the large context of social change. Where so much remains to be done within the field of technology itself, to catch up with its long neglect as a subject for scholarship, there is some excuse for this over-sharpening of the focus. For all that, it would be a serious error to believe that the internal development of any department of technics can be firmly pictured without reference to the culture it served and to the movement of that culture through time. History as a mere record of events, as the annals or brief abstract chronicles of an age, has only an occasional item to contribute to our understanding of technical change: the invention of the canning process during the Napoleonic wars, in response to the pressure of the British blockade, might be cited as such an instance. But history as the interpretation of the changes and transformations of a whole culture must necessarily take account

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of technology as one of the essential components of a culture, which in the very nature of the process affects, and is affected by, the pressures and the drags, the movements and resistances, the creativities and torpidities of every other aspect of society. By the same token, the historian of technology will find his account of technical processes, seemingly isolated from the general flux of events, far more significant when he restores technology itself to its dynamic social context.

One of our difficulties in the past springs, I think, from the fact that the first scholars to give sufficient weight to technological changes were the anthropologists and archaeologists, who dealt with pre-literate societies for which any other data than the bare tools or weapons were largely lacking. Since all the perishable materials of technology had vanished, along with the people who had used them, the stone or pottery artifact came to be treated as self-existent, almost self-explanatory objects, influencing and characterizing the societies that used them. These tools, utensils, and weapons even created strange technological homunculi, called "Beaker Men," "Double Axe Men," or "Glazed Pottery Men": creatures who would have been unrecognizable in their own society. The fact that such durable artifacts could be arranged in an orderly progressive series often made it seem that technological change had no other source than the tendency to manipulate the materials, improve the processes, refine the shapes, make the product efficient. Here the absence of documents and the paucity of specimens resulted in a grotesque overemphasis of the material object, as a link in a self-propelling, self-sustaining technological advance, which required no further illumination from the culture as a whole even when the historic record finally became available.

This tendency to isolate technological history from the general stream of history was supported by the bias of one of the first thinkers to understand the cultural importance of technology: that is, by Karl Marx himself. One must not under-rate his place as a trail-blazing precursor in the history of technology, which half a dozen brilliant pages in *Das Kapital* made secure. But unfortunately he treated economic institutions and technical processes as if they were autonomous and self-determined, and as if other aspects of culture could only passively reflect the central changes

that technology brought about. But if history is more than past politics it is also more than past technology. We have by now, I trust, passed beyond these over-simplified and limited conceptions of the social process. But we must still be particularly on guard against residual tendencies to this kind of distortion of the evidence, in both early and contemporary cultures, because our own society is in fact over-determined by its excessive and almost exclusive preoccupation with technology: and as a consequence we tend to read our own assumptions and habits into the behavior of other societies.

Now, at the very beginning of the record, the belief that technological history can be adequately described without reference to its social context falls to pieces. Let us consider perhaps the greatest of early civilization's technical achievements: the design and construction of the Great Pyramids. What inner development of technology brought about this overwhelming exhibition of technical virtuosity and audacity? Fortunately, we have sufficient data to answer with confidence: no technological inventions whatever, in the narrow accepted sense of new tools and mechanical processes, promoted the building of the pyramids. These formidable works of engineering were constructed, in both the Old World and the New, by peoples who lacked both wagons and wheels and draught animals: there were no mechanical improvements in cutting stone, hauling, and building that incited the rulers of this society to contemplate such a technological feat. To account for the existence of these pyramids, and still more to account for their magnitude and perfection, one must look, not into the workshops, but into the temple. One cannot interpret this sudden enhancement of technological potentiality without canvassing the changes that took place in theology and astronomy and brought about the sudden elevation of kingship, which turned minor kings into major deities. That concentration of power and authority made possible the invention of the first complex machine: the thousand-legged human machine, made of specialized, interchangeable, and replaceable parts, operating from a single control center, which actually built the pyramids. It was the extension of magnitudes in every direction that made possible the building of the pyramids: that, and the new discipline of human regimentation and mechanical organization.

What I would emphasize is that the means of creating the pyramids did not come from the internal development of technics: just the other way round, it was the magnification and exaltation of human power and purpose that came in with the new solar religions, opening up immense vistas in time and space, that made possible the contrivance of an altogether new species of complex machine. The nature of that machine has eluded the historian of technics because he is looking for a contraption of wood, stone, and metal, and does not recognize a machine when it is made of flesh and bones. Yet by being able to invent and deploy this human machine, the Egyptians were able to overpass the limitations of the simple tools and processes of the stone cutter and the builder: so much so that they could even, when they built the Pyramids at Gizeh, discard the small stone techniques of the earlier builders of the step pyramid at Sakkara and impose upon themselves the collossal difficulties of hauling and handling much bigger stones for covering the surface.

Now we live in an age when, often to our own grief, technological processes not merely modify but supplant human purposes: so because we have ABC weapons that potentially can wipe out a whole enemy population, by tens of millions in a single day, we have abandoned our long accepted moral standards and have reverted to the practice of wholesale genocide, as practiced by an Assurbanipal or a Genghis Khan. For that reason I emphasize the contrasting picture presented in early dynastic Egypt: here human purposes determined technological processes. Though technological development of the Egyptians had not gone beyond the stage of simple handicraft, the social development of Pharaonic Egypt leaped over five thousand years of technological history and created an 100,000 manpower machine. This machine actually performed work on a scale that no handicraft culture, without such a mechanical organization, could have accomplished: it produced the equivalent of a whole corps of power shovels, bulldozers, traction engines, mechanical saws, and pneumatic drills, with an exactitude of measurement and a refinement of finish that would still be a theme for boasting today. Yet the invention itself cannot be described, indeed it can hardly even be perceived, without reference to the social conditions that made it possible: particularly the theological assumptions that gave the Pharaoh alone

the immense powers he commanded in the Pyramid Age. Without following that clue, one loses important insights into much later technological history: the association of all large-scale technological enterprises with political absolutism and military compulsion. Contrary to the usual interpretation, the machine is not a product of the industrial revolution of the eighteenth century, nor even of the thirteenth century: from the third millenium B. C. on, efficient machines, in the form of highly organized labor armies, were available; but they could only be assembled and deployed by a central authority whose means of control and coercion were unlimited. Whenever that authority weakened, the machine fell apart and disappeared.

Do not think that this analysis of Egyptian technology has a bearing only on ancient societies, and that none of it is applicable to our present age. I have not the time to bring out the arresting parallels between the Pyramid Builders of old and the Rocket Builders of our own time: but does any one suppose that either atom bombs or intercontinental rockets would have been brought into existence within a single decade except at the command of an all-powerful state, bringing to bear the financial and scientific resources of a vast community in the closed totalitarian situation of war? Neither story can be accurately told without reference to the larger historic context.

This recognition of the interdependence of technological development with all the other dynamic processes in a culture raises many important problems, not all of which can be readily solved. How is it that the principal inventions that supported ancient civilization had all been made by the beginning of the Iron Age? One of the favored answers to this question is that the institution of slavery removed the incentive to invention; and there is considerable merit in this explanation, even if one amends it to say that slavery, or forced labor, made it unnecessary to invent *other kinds of machine* than the work-gang and the army. But are we not forgetting another historic factor that has been insufficiently stressed, namely, the dual role played by war? War not merely absorbed a disproportionately large share of technological ingenuity for its own sterile purposes, even as it is doing again in our own day: but the total war practiced generally by early societies razed whole cities, wiped out their workshops, and killed or scattered

their workers. Since technical processes were imparted by example and verbal instruction—most of it never committed to writing, to ensure secrecy—there was a constant disruption of technological traditions. For this reason, merely to hold on to known processes was perhaps the most that was possible. Significantly, perhaps, the greatest of technological advances, that on which all later inventions depended, the domestication of plants, antedated the rise of civilization and the institution of systematic total war. The long term observations on which plant selection and cultivation depend would have been impossible in a constant state of war.

Let me now pass to another important moment in technological development, when the nature and the tempo of invention cannot be fully understood without close reference to other historic processes. Here again the important factor in technological change comes from the development of religion: in this case, the development of the Benedictine monastery. Not merely did the Benedictine monastery institute a strict ordering of the day, the celebration of the canonical hours, but the Benedictine rule took the curse off work itself, by marking it, not as a degradation but as a moral obligation; and by their orderly conduct of work the monks augmented their own industrial efficiency. In all these ways, the monastery provided a favorable medium, not only for capitalism, as Werner Sombart pointed out, but for mechanical improvement: time measurement, labor saving, standardization, habituation to an orderly life of constant effort and application first took place in the monastery, before they were translated into secular routine. Bertrand Gille has brought forth documentary evidence to show that the monastery, in order to achieve leisure for contemplation, went in heavily for power machinery and other labor-saving devices: the monastery he cites was a model industrial village. I long ago pointed out that to describe the invention of the mechanical clock without reference to the monastic need for temporal regularity is like describing the invention of the ship's chronometer without reference to the exploration and transoceanic navigation that demanded and actively promoted this invention. Though a chain of technical improvements was a necessary antecedent to both inventions, the operative demand did not come from the toolmaker or the watchmaker, but from the dynamics of the culture itself. Long before mechanical invention became a popular pastime,

the monastery had cultivated and diffused the medium in which such inventions would spontaneously flourish.

Since technology is not independent of other social changes, there is no part of the historic complex that may not have an effect upon technological innovation. Certainly, it would be unfortunate if anyone concluded from my illustrations that religion alone has played a major part. What makes general historic perspective so important is the fact that the stimulus may come from seemingly remote parts of a culture. Thus the increased attention to child care in the late middle ages, witnessed by the invention of the cradle, the toddler, and finally, the rocking chair, inventions that belong to the ancient technology of containers, led also to ingenious mechanical inventions in children's toys, such as the magic lantern, the motion picture, the helicopter, all of which served as models and incentives for the mature machines that developed within the following century.

These observations do not, of course, deny that technology, like any other institutional complex, exists within its own peculiar envelope and must be understood in detail with reference to its own needs and problems. But even within the realm where, temporarily, a narrow focus is justifiable, it is impossible to isolate the invention from the inventor, or the inventor from the place and the labor force and the culture that presented him with his opportunities and his incentives—or placed obstacles in his way and rejected his results. If the general historian will increasingly, we hope, remind himself that no adequate presentation of historic events can be made without reference to technological facilities, so the historian of technology must alertly scan and appraise the whole historic milieu, even when examining the minutest segment of technological change. This may result in a slowing down of his productivity in his limited specialized field. But what he loses in time through this more organic and integrated approach, his work will gain in significance.

COMMENTARY: TECHNOLOGY AND THE HISTORY OF IDEAS

H. STUART HUGHES*

I AM WRITING THIS as a thorough amateur and outsider in the history of technology. What I have to contribute springs, first, from a general concern for the history of ideas (in which technology plays—or should play—a decisive role), second, from a long-standing interest in the logic of historical discourse.

My text is taken from the conclusion of Mr. Burlingame's paper: "Machines and processes were made by man for man and never have had or ever will have powers divorced from his." To me this carries echoes of the single passage in historical literature that I find myself quoting most often, Vico's dictum: "Man can understand the civil world because he made it."

For reasons of temperament and prejudice, such as Mr. Burlingame has traced, historians have been periodically forgetting Vico's teaching for the past two and a half centuries. Each generation has had to relearn, frequently with pain, something that should have been part of its common inheritance. And this forgetfulness has not simply been because historians, as literary men, have scorned and distrusted technology and its ways. It has arisen from a basic misunderstanding both of the past and of the historical craft itself.

In other languages than our own, the verbs "to make" and "to do" are close or even identical. The mere word "fact"—the cornerstone of conventional historiography—betrays this near identity. But for most historians the concepts of what is done and of what is made exist in two different spiritual worlds. The one partakes of the autonomy of free and individual human life. The other belongs to the dead world of the material, the mechanical, the repetitious, and the anonymous. These are caricatures, of course; yet I think it undeniable that a profession which has cherished the "human" as its basic concern has almost instinctively

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found something "inhuman" in the processes of technology. It is curious that the very writer who did more than anyone else to restore the influence of Vico to the contemporary world of thought –Benedetto Croce–rejected technological explanations as throwing open the spiritual citadel of historiography to its positivist assailants.

What Croce–and before or after him, the whole idealist school of historians–denied was the "spiritual" character of technology. They forgot that every new device had at some time had an inventor, and that this invention was an authentic act of creation belonging to the same world of human autonomy and of the spirit which seemed to them alone worthy of the historian's attention. They lost sight of the fact that mechanical innovation, no matter how modest, was an event in the history of man's self-realization which deserved the same kind of sympathetic attention–of inner participation by the historian–as the enunciation of a new religious dogma or the promulgation of a new constitutional enactment.

Undoubtedly a further difficulty arose from the fact that technology was largely anonymous–that for most of history the technical innovators were unknown figures or collective entities who did not lend themselves to historical "re-living" as readily as statesmen, artists, or religious leaders. But surely historians–at least since Michelet, to cite another disciple of Vico–have known how to write of collectivities and of the anonymous prime movers of great perturbations. They have known that history is individual only in the sense that both its acting and its understanding are ultimately reducible to the play of a single human consciousness. Yet precisely here lies the confusion. The play of the individual consciousness–whether of past actor or of present writer–has fascinated the historian to the exclusion of nearly everything else. It has led him to forget that men have *made* their history quite literally as workers with their own hands, and that this cumulative construction has of necessity been a process more anonymous than personal.

If historians understood this better they would find salvation from skepticism and relativism–the idealists' recurring nightmares–and with it an appreciation of the artisan nature of their own craft. It is no accident that Marc Bloch wrote of his chosen endeavor as a *métier*. He viewed himself as a craftsman, not merely "re-thinking" or "re-enacting" the past in his mind, as the classics

of the idealist tradition taught, but quite literally retracing with the precision of a technician the basic processes of past eras, whether in patterns of settlement or in the tilling of the soil. And these, he found, since they were tangibly present—since they could actually be confronted by the historian rather than just "rethought" from the dubious evidence of documents—were by their very nature less subject to debate. "What is most profound in history," he declared, "is also the most certain." Artifacts and the attitudes they betokened—and, as Lewis Mumford writes in his paper, Bloch emphasized the meaninglessness of mere "things" independent of the social and spiritual world in which they functioned—these artifacts and attitudes came closer to some bedrock of history than what we conventionally call "events." And the historian who was more a reconstructor than a narrator, Bloch argued, would be far more likely to reach something to which he could confidently give the name of truth.

In my own seminar teaching, I have found that metaphors drawn from architecture or engineering most often express the concept of craftsmanship in history that I am trying to convey. And this not only in the sense of the artisan's ethos of work well done. Such metaphors also suggest a congruence of the historian's mind with the rhythms and work processes of past ages, with the patient and cumulative construction of history, both as what was once made and done, and in terms of the historian's subsequent labors. This, I think, is what Bloch meant when he spoke of our profession as a craft. And it is what many of us mean today when we say that the history of technology is not merely a specialized part of knowledge tucked off in some unfrequented corner of our own discipline, but a way of understanding the past that yields to no other in the sense it gives us of direct confrontation with a living and a human reality.

Master Gunner Apollonios

L. SPRAGUE DE CAMP*

According to Diodoros the Sicilian (XIV, xli-xlii) the catapult was invented by a crew of skilled mechanics, whom Dionysios of Syracuse hired for the purpose when preparing to attack the Carthaginian colonies in Sicily in 399 B. C. Diodoros' account has been questioned but never seriously gainsaid.

During the first four or five hundred years of the history of these weapons, all catapults, as far as we know, were something like oversized crossbows mounted on frames or pedestals. The smaller ones, called *oxybeloi* (dart throwers), shot darts, like massive arrows two to six feet long. The larger ones, called *petroboloi* or *lithoboloi* (stone throwers), shot balls of stone or brick weighing 10 to 600 pounds.[1] A pile of one-talent catapult balls can be seen today near the Ear of Dionysios at Siracusa.

The general classical names for these engines, *katapeltes* (or *catalpulta*) and *bal(l)ista*, meant simply "thrower" or "shooter" —that is, any missile weapon. These words were applied indiscriminately to all classical catapults. Although some ancient and modern writers have tried to limit one word or the other to catapults of some particular type, they have not done so in any consistent way.[2]

"Gun" and *Geschütz* originally had the same broad meaning as *katapeltes* and *bal(l)ista*. Conversely, early cannon were sometimes called *ballistae*.[3]

Catapults may also be classified according to the means they employed to cast their missiles. A catapult of the flexion type had a large bow, of wood or of other springy materials, mounted on a supporting frame, with means for cocking and releasing. In a catapult of the torsion type, on the other hand, the place of the

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solid bow was taken by a pair of torsion skeins, usually of woven hair, through which rigid throwing arms were thrust.

Catapults of the flexion type are described in Biton's *On the Construction of Engines of War and Catapults*.[4] Catapults of the torsion type are described in the writings on artillery by Philon of Byzantium, Heron of Alexandria, Athenaios Mechanikos, and Vitruvius.[5]

Heron also describes the crossbow, which he calls the *gastraphetês* or "belly weapon." Other writers called it the *cheirobalista* or *manuballista*, "hand catapult." The crossbow might be defined as a small portable flexion dart thrower.

From general engineering considerations, we can infer that the flexion catapult came first, and that the torsion catapult was developed from it later. This surmise is confirmed by the fact that one of the catapult engineers mentioned by Biton, as the designer of some of the flexion catapults described in his treatise, is "Zopyros the Tarentine." This is probably the Zopyros of Tarentum mentioned by Iamblichos of Chalkis in the list of Pythagorean philosophers at the end of his *Life of Pythagoras*. As the Pythagorean sect became extinct in the latter part of the fourth century B. C., Zopyros probably flourished in the first half of that century, making him a contemporary of Archytas and Plato.

As Philon, Heron, Athenaios, and Vitruvius all describe torsion catapults but (except for Heron's crossbow) none mentions flexion catapults, it is likely that during their period—from the third century B. C. to the first A. D.—the torsion catapult dominated the flexion catapult, if indeed it did not altogether take its place.

* * *

So far I have merely summarized facts already known to historians of technology. But when did this change from flexion to torsion take place? Certainly it happened before the time of Philon, who described torsion catapults and who, as a pupil of the great Ktesibios, must have written in the later third century B. C.[6] I think I have found how to narrow down the possible dates of this change a little more closely.

In the late first century B. C., Athenaios Mechanikos wrote his *Peri mêchanêmatôn* (*Concerning Mechanisms*), of the same general character as the works on ordnance of Biton, Philon, Vitruvius,

and Heron. Athenaios used some of the same sources as his contemporary Vitruvius, as is shown by closely parallel passages in the two works.

Right after the dedication of this work (to "the illustrious Marcellus") Athenaios quotes a certain Agesistratos on the importance of detailed planning and study. Then he tells what a great engineer Agesistratos was.

Agesistratos, he says, built catapults with 12-pound torsion skeins, shooting 3-span (27-inch) darts up to three stadia (600 yards) and others shooting 4-cubit (6-foot) darts up to four stadia (800 yards). This passage leaves no doubt that torsion catapults were used in Agesistratos' time. But when did Agesistratos live? Athenaios goes on to say:

> Moreover, Apollonios, having become [Agesistratos'] teacher, put such loads of stones upon the mole that surrounded the harbor of Rhodes, that often those who saw them were puzzled as to how he got them on shipboard and how in the world he unloaded them on the ground at Rhodes.[7]

Evidently Apollonios was the chief artillerist, or master gunner, of the attacking army at a siege of Rhodes. Now, Rhodes was twice besieged between the time of Dionysios and that of Athenaios. The first time was by Demetrios Antigonou in 305-304 B. C. By a night attack, Demetrios seized the principal mole that guarded the harbor and occupied it with 400 soldiers. He mounted catapults on the mole and bombarded the defense works of the harbor while trying to force the defenses by troops from landing craft.[8]

The Rhodians beat off Demetrios' attacks and retook the mole. Demetrios then attacked by land. As these assaults fared no better, despite the tremendous siege engines of the attackers, Demetrios finally made a treaty with the Rhodians and sailed away. Athenaios' statement about Agesistratos is consistent with the latter's having taken part in this siege.

Then Mithradates Eupator besieged Rhodes in 88 B. C. Although this siege followed, in many respects, a course much like that by Demetrios, Mithradates did not succeed in taking any of the moles. At least Appianos, who wrote a fairly detailed account of the siege, says nothing of any such incident.[9]

In addition, Rhodes was captured by Artemisia II of Caria about

347 B. C. and by Cassius in 43 B. C. In each case, however, the city was suddenly seized by a ruse, so these do not count. Rhodes was also at war on other occasions, but without sustaining any such attacks on the city.[10]

It follows, then, that Apollonios must have commanded the artillery of Demetrios in the siege of 305. We can infer from Athenaios that Agesistratos was probably an assistant or subordinate of Apollonios at this siege. If this identification of Apollonios be correct, then our Apollonios could not have been the geometer Apollonios of Perga, who was born about 262 B. C. But then, "Apollonios" was one of the very commonest Hellenistic names.

The "loads of stones" alluded to by Athenaios were probably 3-talent (180-pound) catapult balls, which Vitruvius implies (X, xvi, 4) were in use at that time.[11] Apollonios' artillery probably ranged from light dart throwers shooting 3-span darts (mentioned by Diodoros, XX, lxxxiii, 1, in connection with this siege) to heavy stone throwers casting 3-talent balls of stone or brick.

As Agesistratos was a contemporary of Apollonios, and as Agesistratos built torsion catapults, it follows that the change from flexion to the more efficient torsion either was under way or had already taken place by Apollonios' time. We can, therefore, say with good probability that the two-armed torsion catapult had largely replaced the flexion catapult (save, perhaps, in the smallest sizes and in the crossbow) by the end of the fourth century B. C.

Of course, this change did not take place all at once. Flexion catapults, if less efficient, were simpler to build. Therefore they continued in use, as later allusions to them show.

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[1] Plutarch (*Marcellus*, xv, 4) credits a catapult shooting 10-talent (600-lb.) balls to Archimedes. *Oxybelos* means literally "shooter of sharp things." For the weight of catapault balls, see A. G. Drachmann, "Remarks on the Ancient Catapaults," in *Actes du Septième Congrès International d'Histoire des Sciences* (Jerusalem, 1953), pp. 279-82.

[2] For instance, compare Diod. XX, lxxxv, 1: "*pros tous petrobolous, tên de pros tous oxybeleis*"; Vitr. X, xi, 8: "*de ballistis et catapultis*"; Appian.: *Libykê*, XII, 80: "*katapeltas oxybeleis te kai lithobolous*"; Jos., *De Bel. Jud.*, V, vi, 2 (263): "*tous oxybeleis kai katapeltas tas lithobolous mêchanas.*"

[3] Roberto Valturio: *De l'Arte Militare* (Verona, 1483), *apud* Robert Held, *The Age of Firearms* (N.Y., 1957), p. 19.

[4] A. Rehm & E. Schramm, *Bitons Bau von Belagerungsmaschinen und Geschützen*, in *Abhandlungen der Bayerische Akad. der Wissenschaften, Philosophisch-historische Abteilung*, Neue Folge, 2, 1929. Biton's work contains anachronisms and inconsistencies. It is addressed to "King Attalos," which places it in the period 241-133 B.C. (that is, between the accession of Attalos I and the death of Attalos III) but there is reason to think that the catapult designs it sets forth are much older.

[5] H. Diels & E. Schramm, *Philons Belopoiika*, in *Abhand. der Preussischen Akad. der Wissenschaften, Phil.-hist. Klasse*, Nr. 16, 1918; H. Diels & E. Schramm, *Herons Belopoiika*, in *Abhand. der Königl. Akad. der Wissenschaften, Phil.-hist. Klasse*, Nr. 2, 1918.

[6] For the dates of the great Alexandrian engineers, see A. G. Drachmann, *Ktesibios, Philon, and Heron*, Vol. IV of *Acta Hist. Scient. Natur. et Med.* (Univ. of Copenhagen, 1948), pp. 74 ff.

[7] C. Wescher, *Poliorcétique des Grecs*, p. 8; M. de Rochas d'Aiglun: *Traduction du Traité des Machines d'Athenée*, p. 783. I am indebted to Dr. William McDermott of the University of Pennsylvania for help with this translation.

[8] Diod. Sic., XX, lxxxi-xcix; Plut., *Demetrius*, xxi-xxii; Vitr., X, xvi, 1-9; Aul. Gel., XV, xxxi; Vegetius, IV, xx.

[9] Appian., *De bel. Mith.*, xxiv-xxvii.

[10] Vitr., II, xli; App.: *De bel. civ.*, lxxi; C. Torr, *Rhodes in Ancient Times*, Chap. I.

[11] If made of sandstone, such balls would be about 1.35 feet in diameter.

Research Notes

PRELIMINARY REPORT ON EARLY IRON TECHNOLOGY IN POLAND

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METALLOGRAPHIC METHODS have been applied for some time in the investigations of ancient metal objects; H. Bell,[1] R. Hadfield,[2] T. Turner,[3] and others published investigations on ancient iron objects as early as 1912. Since that time several publications have appeared, but the number of the investigated objects was relatively small (less than a hundred specimens). The results of investigations of this type had a rather casual character and did not allow the establishment of the origin of the objects and the development of technology in particular countries. In addition, the investigations carried out up to this time did not take advantage of all the possibilities offered by a modern metallographic laboratory.

B. A. Koltschyn [4] was the first to begin mass investigations of iron objects. Having investigated 286 objects from 32 places, he described the technology of iron objects in Ruthenia from the tenth to the twelfth century. Koltschyn's investigations included metallographic observations, hardness and microhardness measurements, and semi-quantitative chemical analysis carried out with a steeloscope.

Similar investigations of the iron technology on the Polish territories were started in 1955 by the Section of Polish Metallurgical and Foundry Technics attached to the Committee of the History of Science and Technics of the Polish Academy of Science. In the investigations metallographic observations with the classification of the grain size, the microhardness measurements of the structural components with Hanemann apparatus, and the hardness measurements of metals by the Vickers method were employed. Quantitative spectrographic analysis and quantitative chemical analysis were also carried out. In some cases, to determine the microsegregation of phosphorus in iron, the etching of metallographic samples was applied as well as surface etching of tools from the early Middle Ages and examination with X-rays and gamma-rays. Investigations of iron slags originating from ancient centers of metallurgical production were carried out at the same time; these involved quantitative and qualitative chemical analysis

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and determination of the point of softening and melting. When elaborating the results statistical methods were applied.

In the studies of the early technology, writings by classical authors (Pliny, Aristotle, etc.)[5] and later ones (Theophilus, Biringuccio, etc.)[6] were utilized.

Objects originating from the beginning of the appearance of iron on Polish territories till the fourteenth century have been investigated so far: 168 objects from seventy places of the Hallstatt period (800-300 B. C.),[7] 23 objects from nine places from the La Tène period (300-100 B. C.), 208 objects from 43 places from the period of Roman influence (100 B. C.-400 A. D.), and 356 objects from ten places from the early Middle Ages (800-1300) have been investigated.

Although the investigations are not yet finished, the development of the technology of iron objects from the eighth century B. C. to the fourteenth century A. D. is already visible. Smelting of hematite ores in the Świętokrzyskie Mountains probably started in the Hallstatt period (600-500 B. C.), steel with different carburization being obtained; the phosphorus content was very low (less than 0.17% P). It is also probable that the people of Łużyce culture in Wielkopolska (Great Poland) and Silesia smelted small amounts of soft iron with an elevated phosphorus content from bog-ores. Cemented tools appear at the same time on the Polish territories, and welded objects from iron and steel;[8] they were probably imported from other countries.

The metallurgical center in the Świętokrzyskie Mountains greatly increased its production in the D Hallstatt period and La Tène period, and particularly in the Roman period (100 B. C.-400 A. D.), and was one of the largest in Europe. At the same time the smelting of iron spread considerably through the Polish territories. In Wielkopolska bog ores were explored and soft iron was smelted. In the neighbourhood of Kraków (200 B. C.-500 A. D.) iron with a high phosphorus content (0.3-0.4% P) was smelted from the same ores. The tools were cemented and heat treated.[9]

The Jaćwings, living in the North-East territories of Poland were smelting iron with a rather low phosphorus content (ca. 0.1% P) in the III-IV century; the tools were cemented and heat treated.[10]

In the early Middle Ages (ninth century and later) a new technique was being developed in the Polish territories. It was concerned with making the working part of a tool (e. g., the edge of the knife) from steel (hard steel), whereas the remaining part was forged in iron. For example, among the 84 knives of the early Middle Ages investigated 55 (65.4%) were welded from iron and steel. Among the remainder were five steel knives (6%), eleven iron knives (13.1%), and thirteen cemented iron knives (15.9%). From the tenth and eleventh centuries knives welded from two straight bars—a steel one and an iron one (32 knives, i. e., 38.2%)—appear more often.

This method was applied in all early medieval centres of metallurgi-

cal production: in Gdańsk (900-1300),[11] Łęczyca (1100-1200),[12] and others. Almost all the tools made of carburized iron or steel were submitted to an appropriate heat treatment. This indicates the high technical level of the Polish metallurgists and forgers in the early Middle Ages.

This period also possessed a great variety of techniques for manufacturing tools. Twenty different ways of producing knives have been found so far. The highest technical level of this period is represented by the "damascene" knives, three such knives being found on the territory of the old castle on the Wawel Hill (Kraków) and two in Gdańsk.[13]

A simplification of the technology of manufacturing tools may be observed in those dating from the fourteenth century, even at the cost of lowering their quality. The number of ways of manufacture (e. g., of knives) decreased markedly, indicating a tendency towards uniformity of production.

The first objects of fined iron and objects cast from pig iron (a pommel of a sword from Gdańsk) appeared in Poland in the fourteenth century.

From the studies thus far carried out, it is clear that investigation of a great number of ancient objects in all countries is necessary in order to determine the origin of old iron objects and to trace the lines of technological development. If metallographic methods similar to those used in the Polish investigations will be employed in such studies, it will be possible to compare results and, hopefully, arrive at meaningful generalizations.

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Communications

CONCERNING A UNIFIED CONCEPT OF TECHNICAL PROGRESS: ZVORKINE ON DRUCKER'S "WORK AND TOOLS"

(The author of the following communication is historian of technology in the Soviet Union. From 1949 to 1960 he was Assistant Editor-in-Chief of the *Great Soviet Encyclopedia*; he is now Editor-in-Chief of *Vestnik istorii mirovoi kultury* [*Review of the History of World Civilization*]. He is author of over one hundred books and articles on the history, philosophy, and sociology of science and technology.)

To the Editor of *Technology and Culture*:

An article by Professor Peter F. Drucker, "Work and Tools," published in *Technology and Culture* (Vol. I, No. I, 1959-1960, pp. 28-37), is bound to attract the attention of all students of the history and philosophy of technology. Prof. Drucker cites the opinion of the editors of the British five-volume *History of Technology*, who believe that modern technology has become so complex as to defy description, let alone understanding. Drucker, however, is of a different opinion. He believes that modern technology is a central force and exercises a major impact both on man's culture and natural environment. In Drucker's opinion, "we need a theory that enables us to organize the variety and complexity of modern tools around some basic, unifying concept."

In developing this idea, Prof. Drucker stresses that every writer on technology acknowledges the extraordinary number, variety, and complexity of factors that play a part in technology and are in turn influenced by it: economy and legal system, political institutions and social values, philosophical abstractions, religious beliefs, and scientific knowledge. "No one can know all these," says Drucker, "let alone handle them all in their constantly shifting relationship." The typical reaction to such a situation, in his opinion, has always been to proclaim one of these factors as the determinant—the economy, for instance, or the religious beliefs. But this "can only lead to complete failure to understand. These factors profoundly influence but do not determine each other; at most they may set limits to each other or create a range of opportunities for each other."

The author ultimately arrives at a very stimulating idea, suggesting that the history of technology be regarded as an aspect of work: "It is just possible, however, that work . . . might provide one unifying

concept which will enable us to understand technology both in itself and in its role, its impact on and relationships with values and institutions, knowledge and beliefs, individual and society." In considering the elements of work, Prof. Drucker names tools and techniques (" not only must the available tools and techniques strongly influence what work can and will be done, but how it will be done "); the structure and organization of work (" work, its structure, organization, and concepts must in turn powerfully affect tools and techniques and their development "). He makes special mention of the organization of work as " the aspect of work that has probably had the greatest impact on technology " and " is the one we know the least about," and stresses the importance of scientific management which " studies work as operation."

Indeed, studying technology within a system of aggregate work greatly facilitates the understanding of the development of technology both in the past and in particular during the present period. Especially apt is Prof. Drucker's idea that different factors may set limits to each other or create a range of opportunities for each other. But to my way of thinking, this does not preclude us from trying to establish the determinant factor, which I believe to be the development of tools, i. e., technological means as such.

(1) However important the techniques that provide for raising labor effectivity, these techniques are evolved upon a definite material basis—concrete tools. A given totality of tools (technical means) call for one type of techniques, another, for techniques of a different type. Such technical means as, for instance, contemporary automatic systems call for an entirely new solution of the problem of working techniques.

(2) The organization of work is also largely determined by the character of tools used. Thus, the organization of work in an artisan's workshop is vastly different from that at a modern industrial plant.

(3) Scientific management is vested with different meaning at a plant divided into workshops, and at an automated factory.

This, of course, is not to deny that the tools, the implements of labor are in their turn profoundly influenced by the basic factors of work. Moreover, it is only through the development of all the other factors of work that the objective opportunities for the development of tools are realized.

And yet a mere consideration of the elements of aggregate work in their interrelation—even provided the leading role of tools (technical means) is acknowledged—fails to give a unifying concept that would explain the laws guiding the development of technology, for it leaves out man—man who realizes, in keeping with his aims, the possibilities latent in technology and work.

Prof. Drucker dwells on the purposes of technology and in this

connection cites Singer's *History of Technology*, which defines the meaning and end of technology as "mastery of his (man's) natural environment." Drucker points out that according to the concept of Alfred Russell Wallace the purpose of technology is to overcome man's own natural (i. e., animal) limitations. According to this concept (as Drucker presents it) technology enables man, a land-bound biped, without gills, fins, or wings, to be at home in the water or in the air; it enables an animal with very poor body insulation, that is, a subtropical animal, to live in all climate zones; it enables one of the weakest and slowest of the primates to add to his own strength that of elephant or ox, and to his own speed, that of the horse. It enables him to push his life span from his "natural" twenty years or so to threescore years and ten. This is a very imaginative and vivid description of the role played by technology in the life of man. To be more exact, one would have to speak not of the purpose of technology but of the purpose of man in developing it, while the above description deals with the results of scientific and technical progress.

Unless the important problem of the aims and purposes of man in developing technology is analyzed, the laws guiding technical progress will not be comprehended.

In developing technology, men proceed from purposes of two ranges:

(1) purposes inherent in the nature of work, of the natural and scientific foundation of technology; and

(2) purposes that urge man to improve technology and work.

While the purposes of the first range are concerned with the solution of different technical problems, the purposes of the second range deal with the motives that induce men to improve technology and create new technical means. The first type of purpose is determined by the technical requirements of production, the level of science, technology, and scientific and technical thinking, and in the final analysis is limited by the laws of nature. The second type of purpose is fully determined by man's social life. In improving technology, people may proceed from the most diverse social, economic, aesthetic, psychological, political, and other aims. At the surface this type of purpose seems to lack all regularity. Some people are driven to developing technology by their inventive urge, others by ambition; still others seek to lighten their work, to improve their material status, or to dominate other people, etc., etc.

Apart from the subjective purpose, there are also the objective conditions, which are different in the case of different people. In the capitalist world, a man who possesses capital and wishes to improve technology has different opportunities compared to the man who possesses no wealth. Moreover, men sometimes have to contribute

to technical progress irrespective of their personal inclinations: a capitalist owner of an enterprise is bound to further technological progress so as to withstand competition.

The question is, is it possible to find a certain regularity that would provide an insight into this world of human strivings, to sum up, as it were, all individual strivings and arrive at a certain resultant—bearing in mind all the while that the purposes impelling individuals to improve technology are liable to change. In our opinion, it is possible to establish a leading trend providing an insight into the main channel of technical progress. In doing so, we have to take up once more the concept of work—this time preoccupying ourselves not with its scientific-technical but with its social aspect. People engage in work not in isolation, but collectively. It is precisely the relations of production, and primarily the property relations characteristic of a given society, that constitute the other aspect of work. These property, economic relations determine the political and ideological system of society, which alone enables us to fathom the main social purpose of the members of that society, the aims which they pursue in developing technology, and the basic conditions (the economic laws of society) under which people labor. We shall obviously fail to understand the history of technical progress in the USA unless we take into consideration the people's striving to achieve material wealth, competition, and many other factors specified by the nature of capitalist production. The entire gamut of other objective and subjective factors affecting the progress of technology, however important for an analysis of the particular features of this development or of the endeavor of individual inventors, will either be connected with the above-mentioned main trends, or will indicate merely the separate (albeit important) and not the determinant features of technical progress in the USA.

An analysis of technical progress in the USSR, in its turn, will yield a great number of objective and subjective factors, all of them pertaining but to the particular features of that progress. If the laws specified by the nature of economic and social relations of socialism are ignored, it will be impossible to understand the tremendous successes scored by the USSR, a formerly backward country, in the lifetime of our generation. Only an analysis of new economic and social relations that emerged in Russia following the October Revolution allows us to grasp both the main social aspirations of the people and the deep-going changes that have taken place in Soviet technology during that period.

The general conclusion inspired by reading Prof. Drucker's article is that his idea of taking work as a point of departure in trying to understand the development of technology may serve as a unifying concept, provided tools (technical means) are recognized as the determinant factor of work and work is considered both in its natural-

scientific and social aspects; moreover, the economic conditions (property relations) obtaining in a given society and the social system that takes shape on the basis of economic relations should be taken into account, and the purposes of man in developing technology under concrete historical conditions considered from this angle.

A. Zvorikine
Moscow

DRUCKER'S COMMENTS ON ZVORIKINE

(Dr. Peter F. Drucker of New York University is well known for his books and articles. He has specialized in the study of business enterprise as an institution and of management and managing as leadership functions. His books include *The Future of Industrial Man*, *The New Society*, and *Landmarks of Tomorrow*.)

To the Editor of *Technology and Culture*:

It is a great honor indeed to have one's thoughts in respect to the history and development of technology taken seriously by as distinguished a scholar in this field as Professor Zvorikine. I feel greatly encouraged by his support of what so far is, of course, nothing more than a speculative hypothesis, or a heuristic principle.

I wonder however how useful my approach would be, were we to adopt Professor Zvorikine's suggestion and consider tools (technical means) the determinant factor of work. The purpose of my suggestion that work be used as the unifying focus for the study of technology and its development was precisely to make unnecessary any such assumption. My main objection to it is that there will be an endless—and unnecessary—debate on what precisely we mean by "technical means"; it is this debate which, in the past, has hampered historical understanding so seriously.

To give but one illustration. Scholars agree that one of the major changes in the "work" of warfare in the West was the defeat of the armored knight on horseback by the English longbow-men and the Swiss lancers, both unmounted, both lightly armed and highly mobile. An old and respectable tradition (to which Marx gave substantial support) has held that this technological change was of major importance in the emergence of the centrally-governed territorial state over the old and all but independent feudal baron. What were the technical changes? Neither longbow nor lances were very new.

Maybe the "technical means" were the concepts of military organization which, for the first time in almost seven hundred years (at least in the Christian West), brought substantial masses of citizen-

soldiers together under unified command. But as "technology" this too can hardly be said to have been a new invention in the late middle ages; we know that there was complete familiarity at the time with Greek and Latin military writers, such as Caesar, and that the tradition of Roman organized infantry never died out. Perhaps we have to go further back into factors in the economy and society—let us say, the development of cities (where so distinguished a historian as Pirenne would have put the emphasis), which made possible large-scale manufacturing of weapons and organized supply of military force. Maybe it was the general rise in the economic level which made possible prolonged absence of substantial numbers of cultivators, and so on. Everyone of these theses has been argued by distinguished historians. And usually we lose sight of the development in technology and in the work over the disagreement on historical theory.

It is precisely for this reason that I venture to put forth a "systems" concept. To study the history and development of technology as a discipline in itself, and yet as a historical discipline which, as Professor Zvorikine rightly points out, is embedded in human purposes and human evolution, an "operational" concept seems to me to be needed —and yet a concept which enables the student to bring in and integrate all the tremendous number of separate factors whether they be technical, scientific, cultural, religious, social, economic, legal, and so on. This does not take the place of a theory of history—it is not meant to. If it is theory at all and not simply "heuristic principle," it is a theory of technology.

PETER F. DRUCKER
Montclair, New Jersey

WILLIAMS REVIEWS THE REVIEW ISSUE

(Dr. Trevor I. Williams is the editor of *Endeavour*. He was an editor, along with Charles Singer, E. J. Holmyard, and A. R. Hall, of the five-volume *A History of Technology*, which was reviewed at length in the Fall 1960 issue of *Technology and Culture*.)

To the Editor of *Technology and Culture:*

As managing editor of the *History of Technology* project for the completion of Volume II and for the three subsequent volumes, I should like to acknowledge the honour you do that work in devoting the whole of one issue of *Technology and Culture* to its critical analysis. That it has evoked so much scholarly and penetrating comment, both in your journal and elsewhere, is a welcome tribute to the work and to all associated with it.

Objective criticism, provided it comes from those qualified to voice it, is always valuable, and there can certainly be no grounds for complaint if some of your learned reviewers temper their praises with it. All I would wish to do here is to comment, from the editorial point of view, on some of the points that have been raised. In doing so, I can express only personal opinions, but at the same time I have it very much in mind that I would not wish to say anything that might have been at variance with the views of my late colleagues, Dr. Charles Singer and Dr. E. J. Holmyard; I therefore restrict myself to matters on which I believe all the editors would have been substantially in agreement. Dr. Holmyard I knew well from my early youth, and had the greatest admiration and regard for him; I think I can claim that we enjoyed complete mutual confidence. Dr. Singer I was privileged to know only through our work together on this project, but during it we had, of course, to work closely together and I quickly formed a high opinion of his scholarship. My third editorial colleague, Dr. A. R. Hall, contributed to this special issue, and part of what I want to say no more than emphasises his admirable account of some of our problems. Indeed, his article answers—and might have forestalled, had it been available beforehand—some at least of the criticisms that have been made.

In a way, completing a project of this kind epitomizes life itself: it is not what you want, but what you can get. Although the benefaction provided for the project was most generous, it was naturally not unlimited, and we had to work within predetermined limits of both expenditure and time. It was clear from the outset that available resources would permit a reasonably comprehensive "history of how things were done or made" but would not allow any considerable excursions, however tempting, beyond this limit. We therefore specifically abjured any attempt to present a comprehensive history of material civilization. Those reviewers who have remarked how much better the work would have been had it been extended to include more profound discussion of social, economic, political, and other formative influences, and if greater space had been given to the general historical background, are unquestionably right; nevertheless, they urge a course which it was never our intention to follow nor, more to the point, within our resources to achieve. This point is explicitly referred to in the Preface to the first volume: "It might have been well, though it proved impracticable, to preface this volume by another giving an outline of social history for the period covered."

That we might have imparted a greater unity to the selected material may well be true, but some of the criticism on this score seems to ignore—apart from intrinsic practical difficulties—the relative rights and responsibilities of editor and contributor. The editors must naturally give each contributor as clear a brief as possible—indicating the general scope of the chapter, its length, approximate number of illustrations,

the kind of readership for whom the work is designed, date of completion, and so on—so that the complete volume may have the necessary unity. When the chapter is received, there will almost inevitably be—apart from differences in style and approach—matters of fact and opinion on which the contributor differs from the editors or from other contributors. An important part of the editors' task is to try, with persuasive tact, to minimize these differences, but it is essential to realize that they can take the contributor only as far as he is willing to go; they have not the power, nor should they ever have, to attribute to a contributor views with which he is not in full agreement. Carlo Panseri, in his review of the metallurgical sections of the work, succinctly states this major editorial problem: "a work of the size and scope of that under consideration has as its goal to give a comprehensive picture, one formed as little as possible by the particular preferences of the individual contributors." Discrepancies between chapters on matters of generally accepted fact certainly mean that Homer has nodded, though it may fairly be remarked that on examination some facts prove more factual than others. Discrepancies in matters of interpretation, to which Lynn White, jr., among others, refers, may spring from the same human weakness, but may be symptomatic of the fact that the history of technology is still a subject for controversy, often fierce; such discrepancies may mean simply that a contributor has stuck firmly to his own point of view.

Several of your reviewers—such as Thomas J. Higgins writing on Electrical Engineering and Carl W. Condit writing on Building and Civil Engineering—have criticized the bibliographies, either for their unevenness or for their omissions. This criticism is not unjustified, but it is perhaps permissible to remark that the preparation of the bibliographies presented far greater difficulties than were expected at the outset, so much so that for considerable periods during the project they gave virtually full-time employment to one member or another of our staff. It was, of course, never our intention to provide exhaustive bibliographies, with their entries numbered in thousands, such as those on electrical engineering mentioned by Higgins. Bearing in mind the needs of the general reader rather than of the specialist, our aim was to compile—with the guidance of the contributors—lists for each chapter that would enable those who wished to do so to delve more deeply into the subject, in general with the help of books and journals that would be reasonably accessible through normal library services. Even this modest objective proved very difficult to attain, however. Such lists have no value unless sufficient bibliographical details are given for the reference to be unequivocally identified; in innumerable cases our contributors, helpful and patient though they always were, were unable to supply essential details, and an enormous amount of time was spent in trying to find these, not always successfully. We are grateful to reviewers who have drawn our attention to some omissions that

certainly ought to be made good when the opportunity occurs. But, apart from the difficulties mentioned above, the unevenness of the bibliographies also represents both differing views among contributors as to what constitutes a reference suitable for the general reader and the unevenness with which the subject as a whole has been worked over.

The choice of contributor is by no means easy. Not every authority is able or willing to write a chapter on his own topic at relatively short notice, for in the nature of things the ablest men have the heaviest commitments; nevertheless, we were astonished and pleased at the number of eminent scholars who set other work aside in order to collaborate with us. Again, the subject as a whole has been so unevenly studied that there are many topics too important to omit that have nevertheless been only relatively little worked upon; if a somewhat lower standard must then be accepted, one is none the less grateful for the best that the best available contributor can provide.

Most of these general points can be illustrated from the several reviews published in your special issue, but it is convenient to do so with particular reference to that by Professor Woodbury, since this raises so many of them. At the very outset he shows how widely—indeed diametrically—opinions may differ about the interpretation of the history of technology, for he begins by comparing our work with Sarton's great *Introduction to the History of Science*; he concludes that in scholarship "the voluminous Singer *History of Technology* is far from paralleling Sarton's *Introduction*." Yet Joseph Needham, whose monumental *Science and Civilization in China* has rightly earned him an international reputation for scholarship—he has, incidentally, been honoured by the Society for the History of Technology as one of its three present Corresponding Members—has been generous enough to take so precisely the opposite view that it is perhaps permissible for me to quote him. In the *Cambridge Review* he wrote: "When the first volume of this remarkable work appeared, it was justly recognized as constituting one of the really great enterprises of our time. It is comparable with the *History of Science* of Sarton. . . ."

Woodbury believes the publication of the work to be premature, arguing that it should have been prefaced by "at least another generation of scholarly work." This seems to me very questionable, especially when the reasons advanced are that there would then be fewer "errors of fact and interpretation," a problem which I have already considered at some length. Elimination of errors of fact is indeed highly desirable in a work of serious pretensions, and we are naturally keeping, against the possibility of a revised edition, a note of those that have been brought to our attention through reviews or in other ways. In fairness to the many contributors, however, I think it right to point out that by no means all the alleged errors have proved to be such when closely investigated. But is Woodbury serious in suggesting that one more

generation of scholarship—rather an indeterminate period—would see general agreement over interpretation? Surely the lesson of historiography generally is that however sincerely a dispassionate approach is attempted, subjective factors are virtually impossible to eliminate. Despite many generations of intensive scholarly study there are still many major historical episodes—such as the Spanish Armada, or the Gunpowder Plot, or the War of Independence—whose interpretation is still very far from being universally agreed. The years ahead will doubtless see much more unravelling of the facts of technological history, and a correspondingly firmer basis for a synoptic study such as ours, but all the indications are that the skein is far too tangled for a few years to make a decisive difference to interpretation. If the study of history teaches us anything it is surely that a definitive and universally agreed interpretation of events is hard indeed to achieve. So far as the present situation is concerned, Woodbury tells us only what was known from the outset and was made clear in the Preface to Volume I, where it was explicitly stated that the editors "are well aware that their attempt is incomplete and to be regarded as merely a tentative effort." Reynold M. Wik concludes his review of the sections relating to agricultural machinery with a most thoughtful analysis of the problems of preparing a broad synthesis such as this, and puts the fundamental point well: "all knowledge is in flux and . . . scholarship implies only a quest for better answers, not that they can be nailed down permanently."

A further criticism that "the various articles do not represent original research" seems to me misplaced. The proper place for the reporting of original research is surely in the journals that exist for that very purpose. Although we naturally never discouraged our contributors from including original work if they so wished, the primary purpose of *A History of Technology* was to give an authoritative conspectus of the present state of knowledge of the subject as a whole.

Earlier, I referred to the editorial difficulties in finding contributors who were both authoritative and able to conform to the demands of the work, especially as regards collaboration and time of completion. The difficulty is magnified if the editors are separated from the contributors by barriers of space and language. This was a main reason for our depending so much on British contributors, to which Woodbury takes exception. It was doubtless for much the same reasons that in organizing this comprehensive review of the work the editor of *Technology and Culture* thought fit, quite properly, to rely on the comments of thirteen American, two British, and one Italian critic. Woodbury can think of "half a dozen articles for which a non-British author of equal or better qualifications could have been found." This may, or may not, have been true in the circumstances pertaining at the time, but to have had different authors for six out of 158 contributions could scarcely have altered the character of the work, especially

if some of the alternatives had been only equally good, rather than better.

Woodbury raises two further major points of general interest, namely, the allocation of space to different topics and the general scope of the history of technology. So far as the first of these is concerned he is unfortunate in his choice of example. His comment that only seventeen pages are devoted to coal is at variance with the facts. Coal-mining as such is dealt with in two separate sections: one of seventeen pages in Volume III—which is perhaps the one he read—and one of twenty pages in Volume IV. But in addition coal is referred to elsewhere in the work in numerous contexts, such as the "duty" of steam-engines; the smelting of metals; the firing of pottery kilns; in glass manufacture; in the making of coal-gas; and as a source of raw material for the chemical industry. It is not profitable to make an exhaustive analysis, but in fact thirty-seven complete pages are devoted to coal and at least fifty other pages carry significant references to its technological uses. More fundamental, however, is the basis on which space should be allotted when planning such a work. Woodbury's proposal that it should be in proportion to the historical significance of the topic is inconsistent with the clearly explained aims of this particular work. When one is trying to present to the general reader the history of how things were done or made, a prime consideration must be the technical complexity of the machines or processes under consideration, for it is this that largely determines the amount of space necessary to make their nature clear. On this basis, the extraction of coal, a fairly simple procedure almost to the end of the period under review, can surely be relatively briefly dismissed, so making greater space available for more difficult topics. Conciseness is a virtue in this as in any other work. Denis I. Duveen praises Holmyard's contribution to Volume IV, on developments in chemical theory and practice in relation to the chemical industry, as "a model of concise, accurate, and simple exposition that might well serve historians and scientists as an example." It is hard to believe that the reader would have rated the importance of this subject more highly if the chapter had been longer.

In the same context, Woodbury raises the question of what technology comprises. It is clear that here, too, there exist wide differences of opinion. Thus whaling and fish preservation, he asserts, are not a part of technology but merely an art or craft. Yet in the same issue, in his comprehensive discussion of the sections on food technology, Wayne D. Rasmussen takes as a matter of course the propriety of including fish preservation and whaling, and concludes his admirable review by asking "What aspect of technology is more basic to man's existence than the food he eats?" What indeed! One the whole, I think Woodbury's definition is a good deal narrower than most historians of technology would accept, certainly in Europe.

It is perhaps necessary to point out once again that this work was

not written for specialists, but as a contribution to technical education and "to provide students of technology and applied science with some humane and historical background for their studies." Woodbury asserts that the size and cost of the work must alone have defeated this object, but I am happy to be able to assure him that this is not so. Sales have in fact far exceeded our expectations, and are already much greater than the minimum accepted at the outset as justifying the project. Volume I, with which later volumes have kept pretty well in step, has been thrice reprinted, and, apart from sales of the ordinary edition, the work has been issued in the United States in an unabridged edition by the Library of Science Book Club. In the circumstances we have no misgivings about having achieved our purpose; the work is being far more widely read than we had expected.

I have dealt with Woodbury's review at greater length than it might seem to deserve because he raises so many points of general interest. When he expresses opinions at variance with those of some of the distinguished scholars whose reviews have appeared in this special issue of *Technology and Culture* and elsewhere I am naturally content to leave it to others to weigh the issues. But on one point I am specially qualified to express an opinion, and I should be less than just to the memory of my two late friends and colleagues if I failed to do so. In his final words Woodbury dismisses the *History of Technology* as an amateur production. So indeed it is, if the word is used in its true sense, for no men loved their chosen branch of learning more deeply than did Charles Singer and John Holmyard. The high repute in which they were held as scholars by those competent to judge them, and the exceptional tributes paid to them after their recent deaths, refute the suggestion that a project to which they devoted so many years of their lives can be described as amateur in the disparaging sense that Woodbury gives the word.

TREVOR I. WILLIAMS
London

"*TECHNOCULTURE*"

(The writer of the following letter describes himself as a "Consulting Tactician.")

To the Editor of *Technology and Culture*:

A function of our Society is to investigate the interplay between technology and culture. One example might be the effect of printing press development by Gutenberg (1398?-1468) on the spread by Luther (1483-1546) of Protestantism, which, asserting man's direct commun-

ion with God, required a Bible cheap enough for common availability. Equally worthy is the converse: the effect of Bible demand on publishing expansion and printing improvement.

Is not this study sufficiently important to deserve its own name? Our industrial age is a categorizing one, and a term acts as a standardizing and magnetizing force.

Because its two factors are technology and culture, as reflected also in the title of this journal, I propose that the discipline be named "technoculture."

HENRY G. BURGER
New York City

Book Reviews

The Causes of Wealth. By Jean Fourastié. Translated by Theodore Caplow. Glencoe: The Free Press, 1960. Pp. 246. $5.

This excellent little book is a revised and expanded version of Fourastié's *Machinisme et Bien-être*, first published in 1951. It is a stimulating and provocative essay which should appeal to all social scientists and especially to economists and sociologists and those interested in economic development. Its theme is the structural changes in the economy and in society which take place as the result of the continuing improvement in the efficiency of labor in various fields, especially in the production of commodities. By contrast to the existential gloom of much French literary and philosophical writing of the period, this book breathes a reasonable optimism about the progress of mankind which is amply substantiated by properly selected economic and social data. The author takes a long view; he writes with the immortal eye of the historian, not merely out of the personal experience of a contemporary author. He is constantly reminding us, therefore, that we have simply forgotten how bad things were. He describes with a moving clarity the miseries of human life even in the eighteenth century, and he points out that science and technology, far from enslaving man, have in fact liberated him.

The limpid style, charming illustrations, and almost casual manner of approach of this book may disguise the fact that it presents a very profound challenge to a great deal of economic thinking of the present day. This is an age of aggregative economics, whether this is the economics of full employment or the economics of growth and development. The modern economist thinks of the national income as a fairly homogeneous aggregate of "dollars worth." He thinks of economic growth as the growth in this aggregate. Fourastié points out over and over again that it is not a change in a homogeneous aggregate but it is a change in the structure of economic activity which really constitutes economic progress. At one point (p. 226) he actually uses the striking phrase, "the structure of production, or national income." Economists are not accustomed to equating the concepts of national income with the structure of production, that is, the relative quantities of different kinds of commodities produced. Nevertheless, this seems to me a profound insight and one which the present generation of economists needs to reflect upon deeply.

Fourastié emphasizes again and again that a rise in national income in real terms is the same thing as a change in the structure of production.

When a country is poor, its national income or output consists largely of coarse foodstuffs; as it gets richer the proportion of coarse foodstuffs declines and that of finer foodstuffs, simple manufactured commodities, and services increases. As it gets still richer, we find services increasing at the expanse of manufactured commodities largely because of the change in the relative productivity of labor in the production of different things. Thus, the rise in the national income does not consist of an increasing aggregate of homogeneous dollars of constant purchasing power, but as a developing structure of production of different commodities and services in which, for instance, window glass and mirrors pass from being the luxuries of the very rich to being commonplaces of the poor. This process is accompanied by a profound change in the price structure because some things participate in the process of increasing productivity and other things do not. An hour's common labor can buy a great deal more window glass than it could two hundred years ago. It still, however, buys no more haircuts. In the course of economic development, the relative price of services rises strikingly in relation to those commodities which participate in the process of technical change. In view of this radical change in the price structure, it is at least questionable whether the measure of national income in terms of "dollars" of constant purchasing power really means anything at all, or at least means so little that it could be highly misleading.

Fourastié visualizes the process of economic development as a set of structural changes. The initial step is an increase in knowledge of some kind. The second step is the application of this knowledge, within a framework of social organization, to a change in technique, that is, a new way of doing something. This reflects itself in the increased productivity of labor in producing some particular commodity. This in turn requires an adjustment of the whole distribution of the labor force among different occupations and industries. This redistribution of the labor force in turn produces a different structure of output of commodities as well as, perhaps in some sense, an increase in the aggregate output. This change in the structure of output then leads directly to a change in the pattern of mass-consumption.

This view of the nature of economic development leads directly to the question of the relation between social and political institutions and the rate of economic development. Fourastié is highly critical of the social and political institutions of France in the past, and he argues that such progress as has taken place in the past two centuries has been largely in spite of the political and economic institutions, rather than because of them. The profit-making process may serve to distribute resources in relation to the demand for products; the increase in the productivity of labor, however, comes as an incident in the search for profit rather than as a conscious and a deliberate effort. The author is perhaps too pessimistic about the stimulus which market-oriented

institutions can give to the rise in productivity, and his emphasis on structure at times leads him to neglect or even to deny the importance of autonomous aggregates such as the money supply. Nevertheless, the questions which he raises are disturbing enough to merit serious attention.

In a brief review it is impossible to do justice to the richness of the illustration or the many illuminating comments of this book. It is a rare pleasure in these days to find a book that is both profound and unsophisticated. This book is profound in the sense that it goes to the heart of the economic and social process in the last two or three hundred years. In an existentialist decade this book captures an essence —the essence of the great revolution through which we are all passing. It is unsophisticated in the sense that it does not use any elaborate mathematical models or complicated theories. This is the sort of book which does not receive the attention it deserves if it is confined to its original language for, although the illustrations are mainly French, the theme is universal. The English-speaking world owes a debt of gratitude to Dr. Caplow for making this book available in an excellent translation.

KENNETH E. BOULDING *

Sociological Aspects of Economic Growth. By Bert F. Hoselitz. Glencoe: The Free Press, 1960. Pp. 250. $5.

The problem of economic growth, especially for the economically underdeveloped countries, but for the more developed ones as well, has for some time now been an urgent practical problem and one which has attracted a good deal of theoretical and research attention from specialists in several different disciplines of social science. A basic new development in the social science approach to this problem is the only apparently obvious conception that economic growth is not at all a matter of economics and economic change alone. We can now see that all parts of a society are involved in economic change, as forerunners, as concomitants, and as consequences. Those who desire to create economic growth, to plan for it, or to predict its course, must look to the whole range of its sociological accompaniments, such as changes in education, religion, values, the family, government, local community organization, social stratification, the communications system, science and technology, demographic factors, formal and informal social organization, and several other variables.

* Mr. Boulding is professor of economics at the University of Michigan. His writings include *A Reconstruction of Economics*, *The Organizational Revolution*, and *The Skills of the Economist*.

In sum, economic planning must now be social planning in the broadest sense.

One of the American scholars who has done much to formulate and communicate this new point of view is Professor Bert Hoselitz of the University of Chicago and its Research Center in Economic Development and Cultural Change. Over the past decade, in a series of essays published in the journals of several countries, he has tried to develop some theories, and the resultant practical strategies, for dealing with economic growth. Nine useful essays have now been collected in the volume under review here. In one essay, Professor Hoselitz, starting with the mercantilistic writings, proceeding through Marx and the German historical school, and ending with contemporary work, reviews a number of past and present theories of economic growth. In another, he warns of the dangers of certain kinds of theory. The danger of excessively general theories, for example, is that they do not allow the scholar or the planner to come into close enough contact with concrete historical experience or contemporary empirical reality. The danger of theories too closely oriented to policy, on the other hand, is that they try to apply simple formulas to social situations that are too complex to be comprehended by them. Throughout this collection, Professor Hoselitz makes constant use of comparative empirical data—from different societies, from different historical epochs—and this comparative perspective provides a useful alternative to more controlled experimentation and manipulation of social situations.

One of the repeated themes of Professor Hoselitz' essays is the caution that our social sciences theory and research are still inadequate to the large demands made upon them to explain economic growth. However, he offers a number of pieces of theory to help along the way. Perhaps the one he applies most frequently and extensively is Professor Talcott Parsons' schema of pattern variables, or set of generalized modalities for the analysis and comparison of different social systems. Other pieces of theory that he uses include Schumpeter's ideas about entrepreneurial innovators, Park's concepts of cultural marginality, and a number of notions—treated by Hoselitz at length in the last three essays—on the relations between urbanization and economic growth. In the absence of satisfactory generalized and systematic theory, this eclecticism has its virtues, but it is obvious that much remains to be done by many different social scientists if their knowledge is to be of any great help in actual programs for planning economic growth.

One important empirical generalization seems to emerge from all this, and Hoselitz puts it clearly in his statement that there are "various paths of growth and various patterns of social reorganization" possible for different societies that wish to plan for economic growth. Given their different past and present socio-cultural situations, there is no one way to develop all societies and their economies. In the inade-

quate state of our present knowledge, we cannot, of course, say just how much choice there is, or how wide the range of alternatives is; but limited alternatives do definitely seem possible. A spirit of scientific objectivity and tentativeness is much needed in our ideas about economic growth. That spirit would be valuable for actual program planners as well as for scholars seeking to create a more adequate explanatory theory.

BERNARD BARBER *

A History of Metallography: The Development of Ideas on the Structure of Metals before 1890. By Cyril Stanley Smith. Chicago: The University of Chicago Press, 1960. Pp. xxii, 291. Illustrations. $8.50.

This reviewer has often commented on the curious lack of books on the history of metallurgy, in any one or all of its branches. With the extraordinary influence metallurgy has brought to bear for more than two thousand years on society, it has seemed so strange that scientists, engineers and historians have been so neglectful. Now, within one year two important books have appeared, the first the two-volume book by Professor Aitchison (*A History of Metals*), rich in information though wordy, and now this fine book by Professor Cyril Stanley Smith—both by professional metallurgists, fully knowledgeable of the subject, and fully able to view the accomplishments of the past with discerning professional eyes. This is a beginning; the field is rich, with much left to explore and interpret.

Professor Smith is well known to the readers of this journal, for he has written for it on various occasions. His own research accomplishments in the field of metallography have been most important; in recent years he has turned increasingly to the history of metals. In collaboration and in editing his name has appeared on translations of a series of old metallurgical classics: Réaumur's *Memoirs of Steel and Iron* (1722), Biringuccio's *Pirotechnia* (1540), and Erker's *Treatise on Ores and Assaying* (1574). Long director of the Institute for the Study of Metals at the University of Chicago, he now devotes his full attention to the history of science and technology in his professional field, as a member of the faculty at the Massachusetts Institute of Technology.

The whole field of metallurgy is much too large to be encompassed in one volume. Wisely, the author restricts himself to one branch, namely, that of his own speciality, metallography. By that term the initiate means those parts of science and technology that relate to the

* Dr. Barber, Professor of Sociology at Barnard College, Columbia University, is author of *Science and the Social Order.*

structure of metals and alloys, particularly as to what may be seen under the microscope (or in some cases by the unaided eye) either on polished and etched surfaces or on fracture surfaces, and, historically, as this related to the development of the corpuscular theory of matter and a little later to the development of knowledge of the crystalline state. There are special aspects to the study of metals, often not appreciated by professionals in other disciplines; as the author says:

> Engineers and metallurgists have always been forced to try things empirically with nothing but a general background of theory to guide them. They have used and they will continue to use, matter under conditions that cannot be analyzed by precise physical theory, and in so doing they sometimes observe and roughly explain new types of behavior. Indeed unless physics develops better means of handling systems of intermediate complexity, experiment will always prove better than theory.

Restricted to metallography, little or nothing will be found in this volume on the early discoveries of processes for the making of metals from ores, early methods of forming, in a word, early technology; nor are technological advances in the time period covered in any way elaborated, for example, the development of tonnage methods of manufacturing steel, in particular, the Bessemer and the Siemens–Martin (open-hearth) methods, which so revolutionized society; nor do we find an account of the development of elasticity and plasticity theory, of the growing knowledge of the electrical and magnetic properties. These are not omissions; they merely define the limits of coverage of this book within the almost unmanageably extensive general field of metallurgy.

The book is dedicated "To those craftsmen whose intuitive understanding of materials provided the seed from which metallurgical science grew." The introduction states: "(This book) is published in the belief that scientific metallurgy provides a good illustration of the complexity of the development of human knowledge, for it depends on the interaction of theory and empirical knowledge in a way that is not so evident when tracing the growth of the pure sciences." Professor Smith is properly fascinated by the interaction of the craftsman in the arts with the scientific philosopher. Accordingly he begins his book with an account of the work of the swordsmiths, armorers, and jewellers, workers who, endeavoring to produce articles at once beautiful and useful, learned much about the nature of metals.

Starting with the Merovingian pattern-welded blade, he proceeds to the etching of armor, to the famous Damascus blade, to "Damascus" gun barrels, to similar blades of similar metallurgical complexity developed in the Malayan archipelago and in Japan. Some sixty-five pages are devoted to this. Methods of manufacture are described, with drawings; the illustrative photographs of these several blades are magnificent.

He then turns to an account of the seventeenth century corpuscular philosophers, especially Descartes, quoting from him, and from Perroult, Rohault, Huygens, Newton, and many others. There was little knowledge in this period of the structure of metals; the great Réaumur in this same century did indeed begin a study of the fracture of steel and a consideration of the nature of steel. Shortly dendrites were observed, and the shape of polyhedra packed in space was debated; and, in the early part of the nineteenth century, Widmanstätten polished and etched a meterorite, discovering the extraordinarily beautiful crystallographic pattern which has ever since borne his name, and the study of which led and still leads to many important advances in metallography.

Photomicroscopy began with Sorby, in England in 1863. In a way this book centers around Sorby, as it should, for Sorby's work is indeed central in the history of metallography. The account of Sorby's work and that of his successors in the field is quite complete, with much quoting from original sources.

Thence follows the history created by Tschernoff, Percy, Martens, Heyn, Sorby, Osmond, LeChattelier, Brinell, including the Americans Albert Sauveur and Henry Marion Howe. This time-period, 1860-1890, was the great period, when metallography grew out of its fumbling youth. As the author says, "(This) exciting period of development almost all rotated around the understanding of the hardening of steel, which is one of the most complex things, even today not fully explained." There were truly great men then. At this late date it is easy to see all that has come out of their early difficult endeavors. The account that Professor Smith gives of this period is much the most complete and interesting this reviewer has ever seen.

The account ends with the year 1890. The choice of this date is of course arbitrary. In a way, this year marked the end of the heroic age in metallography. The battles waged in dim knowledge, particularly with respect to the theory of the constitution and of the hardening of steel, had been essentially won in the sense that the course that research should take had been defined and the simple principles ascertained.

The book has two appendices: (1) a reprint of "Experiments of Etching upon Iron and Steel," by Kinman, 1774, and (2) a reprint of "On the Microscopical Structure of Iron and Steel," by Sorby, 1885. It is concluded by twenty pages of bibliographical notes and an index.

Perhaps this is sufficient to show something of the nature of this book. Much original historical research has gone into its composition, and much devotion. The printing is most attractive, the illustrations are superb, and the style of writing is most distinguished—the book is a delight to read. This book is a classic. One can only hope that

Professor Smith will, in his new post, continue his labors in this field. He stands nearly alone.

ROBERT F. MEHL *

The Fifteen Wonders of the World. By René Poirier. Translated by M. Crosland. New York: Random House, 1961. Pp. 400. 54 Plates. 54 line drawings, diagrams, and maps. $5.95.

The author, who is not a professional engineer, gives a very readable popular account of some of the most important engineering projects in history: the tower of Babel, the pyramids, the Great Wall of China, the Roman roads, the palace of Versailles, the laying of the trans-Atlantic cable, the American transcontinental railways, the London underground, the Tay and Forth bridges, the Eiffel Tower, the Panama Canal, the Simplon Tunnel, the reclaiming of the Zuyder Zee, the Volga and Tennessee hydro-electric dams, and the Oak Ridge atomic power project. The illustrations and line drawings are mostly well-chosen and informative.

The chapters on which the author has had the opportunity to collect first-hand information, such as those on the Eiffel Tower, the Simplon Tunnel, Versailles, and the Panama Canal, are excellent examples of the vulgarization of the history of technology. In other cases, however, the author had to rely on second-hand information. Unfortunately, as a great historian of science once said, one has to know ten times as much as one prints, and this is not the case where the author discusses such problems of archaeology as the pyramids and the Mesopotamian ziggurats. Here he has not sufficient knowledge of those ancient civilizations which form the background of his story, and he misses many important points by lack of knowledge of the original texts. Thus his story of the religious meaning of the pyramids is lop-sided, and it is useless to repeat the "crane" story reported by Herodotus, which has now been rejected by all competent archaeologists. On the same page 56, we meet one of the other drawbacks of this book, the use of unsuitable translations of ancient texts. The de Selincourt translation of Herodotus, however readable, is a poetical rendering of the original; if one wants to discuss details of this text one should use scholarly translations such as that in the Loeb Classical Library.

* Dr. Mehl is Professor of Metallurgical Engineering at Carnegie Institute of Technology and a consultant to the United States Steel Corporation. He is the author of some 150 papers on metallurgical subjects and a *Brief History of the Science of Metals.* His eminence in the field of metallurgy is attested to by the many medals and awards which have been bestowed upon him and the honorary degrees which have been granted him.

Those chapters written from second-hand information, such as that on the reclamation of the Zuyder Zee, make easy reading, but these stories have already been better told by scholars possessing more information. Van Veen's account of the Zuyder Zee, for instance, gives more data which the historian of technology would like to see, because van Veen was a civil engineer who knew what data were interesting. This chapter is, by the way full of mis-printed Dutch words: nobody would recognize "Prime Minister Poovliet" (page 329) as "Tak van Poortvliet"; nor is "Den Oever" to be explained as "Pine Beach" (there is no pine for miles around!), for it simply means "The Shore." Similar remarks hold good for the chapter on Oak Ridge, which story is much better told in the Robinson book quoted by the author.

The translator has also failed in certain respects. She has not recognized the fact that the transliteration of ancient names differs from language to language. Thus the French "Khou-fou" should be "Khufu" in English! The rendering of Genesis 10 on page 22 is not in accordance with the Authorized Version, 10.4 here being represented as preceding 10.1-3! The quotations of Flavius Josephus, *Jewish Antiquities*, I.113-118, have probably been translated from a French version, as they are a very free rendering of the original.

Hence this book can not be classed as a scholarly work on some of the most important engineering works in history. It can be read with pleasure, for it reads easily, but it should be used with care, and its documentation must be checked in the original publications quoted.

R. J. Forbes *

The Story of Chemistry. By Georg Lockemann. New York: Philosophical Library, 1959. Pp. 277. $4.75.

Georg Lockemann, born 1871, has a well-deserved reputation for his teaching, his experimental work in analytic and physiological chemistry, and for his special studies in chemical history. Some time ago he published a small, two-volume *Geschichte der Chemie* in the pocketbook editions of the Sammlung Göschen, Berlin: the first little volume appeared in 1950 and brought the story up to Lavoisier, the second in 1955 went from the discovery of oxygen to "the present." Appropriate to the purpose of the Sammlung, it was a rather conven-

* Professor Forbes, of the University of Amsterdam, is the author of *Man the Maker* and *Studies in the History of Ancient Technology*. In 1959 he was elected to Corresponding Membership in the Society for the History of Technology. Apart from his historical research and writing, Dr. Forbes served for many years with the Royal Dutch-Shell Corporation.

tional summary, and, influenced by the cultural currents of the time shortly after the war, it had a strong nationalistic tendency.

Ever since Adolphe Wurtz dramatically proclaimed that chemistry was a French science, some historians in England and in Germany have felt justified in putting forth their own national claims. Historically considered, such national ambitions have contributed to the interest in the history of science, and the distortions offered as objective truth by one group have challenged others to show the real facts. Lockemann's prejudice for Joachim Jungius, for example, follows the arguments which Paul Walden brought forth in order to deprive Robert Boyle of the "fatherhood" of modern chemistry. Jungius's scholastic speculations are too characteristic of the man and his time to deserve such misrepresentations. On the other hand, Lavoisier is criticized so intensively that his real importance is dimmed. In the chapters on the nineteenth century, Liebig, Wöhler, and Bunsen are the only heroes. All the other chemists are presented only by incomplete and rather disconnected inventories of their work. Even such inventories could be useful for a quick survey, if they were not marred by errors of fact and lapses of expression. Berzelius is credited with an essential contribution that Ostwald made to the concept of catalysis. The passages on the phase rule, on entropy, on p_H as the symbol for hydrogen ion concentration give completely wrong impressions or none at all.

The Story of Chemistry as published by the Philosophical Library contains no indication of the fact that it is Lockemann's book of 1950-1955 transposed into English. I cannot say "translated" because this English text does not deserve to be called a translation. Whatever merits there are in the German book are obliterated in this English version. In several places, the meaning of the original is entirely perverted in the new form. On page 213, it says: "In 1890, Fischer startled the chemical world by discovering hydronitric acid (HN_s)." In the original the discovery is rightly attributed to Theodor Curtius, but this is done in a dependent sentence which was too difficult for transposition into English. And, besides, "Stickstoffwasserstoffsäure" is called hydrazoic acid. Ipatieff is presented as the man "who discovered in 1910 the strengthening effect of Mixed Catalysts. . . ." (p. 235). These are, unfortunately, no exceptions. The many errors of the original are thus compounded in the English, which, in addition, contains a large number of misprints, not all of them as easily corrected as the formula for the gas law written as "$p + v = c$"! Not even the few structural formulas of the German text are reproduced, the subject index is omitted, and the short bibliography in the Göschen volumes was deemed unnecessary for the New York edition.

The publication of this book is a disservice to the author and a disgrace to the literature on chemistry. It is best to forget that it ever

happened under the name of a man for whom I maintain my deep respect.

EDUARD FARBER *

History of Greek Fire and Gunpowder. By J. R. Partington. Cambridge: Heffer & Sons, Ltd., 1960. Pp. xvi, 381. Illustrations. 70s.

The problem of the origin of gunpowder, and of its most important ingredient, saltpeter, is very confusing. This is due in part to the difficulty in interpreting the meaning of passages in old manuscripts and older languages which describe various types of incendiaries such as burning arrows, projected fire, and other forms of inflammatory weapons, not to mention early fireworks. The meaning of technical words in ancient times is very hard to determine, and a surprisingly large number of modern writers on the subject considered in this book have been guided in their choice of a translation more by their preconceived idea of how things should have been than by any objective attempt to find out how they were. As examples we may note the large number of authors who would like to push a knowledge of saltpeter back to a very ancient date, and the attempts of some German writers to give all credit for the discovery of cannon to their countrymen.

It is against such prejudiced views that Partington has directed his book. This is at once a comprehensive history of all types of inflammable weapons and a basic guide to the original literature. The number of manuscripts which the author reviews is truly amazing. All of the familiar standard writings are here, and so are a great quantity of little known writings which throw light on one or another phase of the problem. There are copious direct quotations, given in the original language, and so the text abounds in Greek, Latin, old German, French, and Dutch, as well as the modern forms of these languages. There are many examples from Arabic, Mongolian, Chinese, and other exotic languages. Usually translations or paraphrases are given for these quotations, but this is not always the case. Furthermore, the quotations tend to break up the text and thus do not make for easy reading. The slightly disorganized style of the book adds to this difficulty. For example, although all types of flame throwers and explosives are discussed in all parts of the book, a systematic classifi-

* Dr. Farber, retired chief chemist of the Timber Engineering Company, published his first book on *Die Entwicklungsgeschichte der Chemie* in Berlin, 1921. He is also the author of *The Evolution of Chemistry* (1952) and *The Nobel-Prize Winners in Chemistry* (1953).

cation of their terminology is not offered until page 266. Thus the book's greatest value is as a reference work rather than a source of painless acquisition of knowledge.

However, as a reference book, the text probably has no equal in its field. Problem after problem is taken up, and by a careful critical study of the literature the most probable solutions are given. The secret ingredient in Greek Fire must have been a distilled petroleum product, not saltpeter. The legend of Black Berthold is shown to be just that. The contributions of Albertus Magnus and Roger Bacon are properly evaluated. The prejudiced German claims for the invention of cannon are refuted by numerous quotations from original manuscripts. The actual contributions of the Arabs and Chinese and their interrelations are discussed in detail. A final chapter on the history of saltpeter itself includes much valuable information on the history of the manufacture of soap and alkalis.

The book contains many illustrations taken from contemporary manuscripts, copious notes, and indexes of names, places and nationalities, subjects, and Greek words. It is a beautiful example of book making.

Thus this text is much more than a history of gunpowder and Greek Fire. It is a comprehensive source book on incendiaries of all kinds and of the substances and processes involved in their manufacture. It will undoubtedly long continue to be of the greatest value both to historians of technology and to historians of all phases of chemistry.

HENRY M. LEICESTER *

Guinness's Brewery in the Irish Economy, 1759-1876. By Patrick Lynch and John Vaizey. Cambridge: Cambridge University Press, 1960. Pp. viii, 278. 2 Fold-out Charts. $7.00.

This is one of two volumes marking the bicentenary of the great Guinness brewery. It tells the story from 1759 to the dissolution, in 1876, of the partnership between Sir Arthur Edward Guinness and his younger brother Edward Cecil, leaving the latter in sole control. The subsequent history of the brewery will be told in a companion volume by S. R. Dennison and Oliver MacDonagh.

As its title indicates, this is primarily an economic history, and although the historian of technology will find much to interest him he will learn little about the development of brewing techniques. This

* Dr. Leicester, Professor of Biochemistry at the College of Physicians and Surgeons of San Francisco, is the editor-in-chief of *Chymia, Annual in the History of Chemistry*. His books include *Historical Background of Chemistry* and, with Dr. Herbert Klickstein, *A Source Book in Chemistry*.

is a pity, for there are many points at which curiosity is roused but not satisfied; for example, it would be interesting to know more of the devices introduced in the 1830's for cooling the wort and of the later importation of ice from Norway for the same purpose. However, it is always unfair to criticize a book because the authors set themselves a goal different from that which some readers would have liked. The question, therefore, is how far the book achieves the aim defined in its title.

In general, it does so very well. From discussion of the complex interplay of economic, demographic, social, political, fiscal, family, and other factors emerges a very fair picture of how and why one of the world's great breweries came to be established in Dublin when it did. Although the emphasis throughout is naturally on the brewing industry, much interesting light is thrown on the Irish economy generally—particularly on the curious anomaly of two quite different economies long existing side by side within a small country. On the coastal fringe to the east was a maritime economy which for most practical purposes was an extension of that of England. In the remainder of the country, containing perhaps three-quarters of the population, the economy was a subsistence one with virtually no circulation of cash. A parallel, if not a close one, is to be seen in modern Italy, with its sharp economic difference between North and South. Two major events contrived to unify Ireland economically after years of neglect. One was an Act of God—the succession of failures of the potato crop in 1845-1850 (complete in 1848) that is remembered as the Great Famine; this tragedy caused a considerable, though far from adequate, influx of capital for relief works. The second was the rapid development of the railway system after 1848; this had a great effect in reducing transport costs and facilitating the movement of the remaining population. During the Great Famine the population had dropped from 8 to 6 million as a result, roughly equally, of disease and emigration, mainly to the United States.

Both these major factors in the creation of the modern Irish economy raise points of much interest to the historian of technology. For those who suffered, the Great Famine was catastrophic. Yet without it the development of the country would have been retarded for decades, to the detriment of later generations. Looked at dispassionately, had techniques of blight control been available in the 1840's this might not in the long run have been to Ireland's advantage. Conversely, the effects of the extension of the railways is a striking reminder of the far-reaching effects of the introduction of a single technological innovation; this can, of course, be paralleled in many other countries at about the same time.

A great deal of information is contained in this volume, but some compression of it could have been made with advantage. In particular,

a good deal of the statistical information could have been printed more concisely and clearly in tabulated or graphical form. Again, there seems to be rather more detailed information about the Guinness family than seems strictly necessary; this is, of course, understandable in view of the great interest of Arthur Guinness, Son & Company, Limited, in the work. However, these are minor and subjective criticisms. Fundamentally the book is excellent and makes most interesting reading. The Cambridge University Press is to be congratulated on this useful addition to the very limited literature on the history of brewing. The book is an admirable companion to Mathias's *The Brewing Industry in England, 1700-1830* published by the same press in 1959. Also to be noted by those who want to read further is *The Brewing Industry, 1886-1951* by one of the authors (J. V.) of the present work, published in 1960.

TREVOR I. WILLIAMS *

War in the Modern World. By Theodore Ropp. Durham: Duke University Press, 1959. Pp. xvi, 400. $10.

Professor Ropp of Duke University has brought forth a distinguished one-volume history of military affairs spanning the past five centuries. It is superbly annotated and brilliantly balanced in its interpretation.

Based upon nearly twenty years of teaching military history on an American campus, in itself a rarity, the basic contribution of *War in the Modern World* is found in its central thesis: political, technological, and organizational features of warfare in history are indivisible. To stress the importance of one or the other of these groups of factors would be misleading. In essence, Ropp's is a commanding call for the total study of war in history as a complex social phenomenon, and one which should find a warm and sympathetic reception among the serious students of technology and culture.

His political, or first, group of basic factors in military history—social, economic, and diplomatic influences—embraces the meaning of war defined as a conflict between nation states, as distinct from other forms of social violence in the past. This is the core of the nature of war as stressed by the nineteenth century student, Karl von Clausewitz, and his latter day disciples, all too prominent in recent historiography. Such an approach by itself is clearly inadequate.

Ropp's second set of basic factors concerns technology broadly considered—"Force armed with the inventions of art and science."

* Dr. Williams is the editor of *Endeavour* and was one of the co-editors of the five-volume *A History of Technology*. He is co-author, with T. K. Derry, of the recently published *A Short History of Technology*.

Weapons of offense and defense endowed with superior firepower and mobility, traced from the heavily-armored and mounted lancer to the nuclear submarine armed with nuclear-tipped missiles, have increasingly exercised a discernable influence upon warfare. By the twentieth century, the scientist, engineer, and manufacturer became as important as politicians and generals, both in the conduct of military operations as well as in the waging of peace. There is no need to recount the evolution of mobility, mechanization, and munitions here.

The organizational, institutional, and administrative factors in military history, Professor Ropp's third group of major determinants, are intimate with the previous two, politics and technology. The organizational factors embrace a host of specialized approaches attractive to contemporary students–strategy, tactics, logistics, command, communication, leadership, training, discipline, management, and the like. Such factors are of great interest to historians in documenting the interrelationships between science and technology and organized human activity.

Space does not permit recital of this volume's contents except in broadest outline. Ropp first treats the "Age of the Great Captains." He then traces land and naval warfare from the Renaissance to the Neoclassical Age (1415-1789), followed by an examination of traditional Anglo-American military thought and consideration of the impact of the French Revolution and Napoleon.

The second part of this pioneering volume is devoted to the Industrial Revolution and its influence upon war in the nineteenth century. Ropp examines in some detail the wars of the mid-century and the uneasy peace between 1871 and 1914. "The Age of Violence," covering the World Wars and the twenty year armistice sandwiched between them, is the final part. In an Epilogue, Professor Ropp outlines a bipolar world in the era of global-legged vehicles armed with city-busters which came into being during the swift decade after the end of World War II. The unhappy problems of protracted cold war, civil defense, limited war, and total war and its prevention in the seventh decade of the twentieth century are defined from a historical perspective. No overfacile solution for the waging of effective peace in our present time of troubles and technology is prescribed. Yet the basic problem seems the clearer from the author's discussion.

Warfare in history, similar to technology, has not enjoyed its share of dispassionate attention from American scholars until very recent times. The liberal anti-military tradition, however admirable a prejudice, has encouraged greater specialized effort in the documentation of political, economic, and social history. But in expanding the breadth of analysis and documentation to include the role of science and technology in its context, consideration of the military aspects seems clearly recommended.

War in the Modern World is not free of minor defects, as in any massive survey. His well-annotated documentation, for example, is limited almost wholly to books generally available. Yet this volume seems indispensible as an intellectual stimulus for any serious student of history. It submits a coherent thesis of military history in the Western World. And this, in turn, provides fresh insight into the broader impact of technology upon society. In short, Professor Ropp's contribution comes as close as any volume will to filling the crucial need for a balanced single volume on military history, broadly considered.

EUGENE M. EMME *

Medicine and Society in America: 1660-1860. By Richard Harrison Shryock. New York: New York University Press, 1960. Pp. viii, 182. $4.

This book consists of the Anson G. Phelps Lectures delivered in 1959 at New York University, a lectureship devoted to early American history. The four lectures include "Origins of a Medical Profession," "Medical Thought and Practice: 1660-1820," "Health and Disease: 1660-1820," "Medicine and Society in Transition, 1820-1860." Skillfully presented in entertaining lecture style, Professor Shryock's book reflects a long career of scholarly application to American medical history. While many of the facts are well known, his masterful retelling and perceptive analyses add a deeper level of interpretation than is commonly found in American medical historiography. As the title indicates, the lectures discuss the *social* history of American medicine, the areas in which medical personnel and institutions are influenced by or interact with their social environment; they do not treat, except incidentally, the history of individual physicians or the history of medical discoveries in America.

A great deal of attention is paid to questions pertaining to regulation, licensing, and education of medical personnel. American medical institutions are correlated with their British prototypes, a study which shows with crystal clarity how a different social environment, such as colonial America in contrast to the British Isles, produces changes in the established patterns in every aspect of medical care and institutions. And later, when independence was won, an even more distinctive character set American medicine apart from its British antecedents.

Professor Shryock presents an excellent review of medical thought

* Dr. Emme is Historian of the National Aeronautics and Space Administration. He edited *The Impact of Air Power: National Security and World Politics,* and his volume *Aeronautics and Astronautics: An American Chronology of Science and Technology in the Exploration of Space, 1915-1960* will appear soon.

in this period (why 1660 is particularly specified as the opening date rather than 1607 is not explained, for actually the entire colonial period is discussed), a difficult task because of the many rival medical doctrines. The chapter on "Health and Disease: 1660-1820" sketches the general picture of public health and personal hygiene and contains the only direct references to technology. Technological improvements, such as the introduction of crop rotation in the eighteenth century, the invention of the cotton gin, and improved communication, supplied more abundant resources which helped to raise living standards and thereby bring better health conditions. After 1800 cleanliness in cities was facilitated by public waterworks made possible by the availability of efficient steam-pumping systems. The negative aspect of technological change in America was, of course, the appalling disease and death rate of slum dwellers in the larger American cities in the nineteenth century, a situation brought about by increasing industrialization. By 1860, when Professor Shryock concludes his study, an organized sanitary reform movement was under way to counteract these new health hazards.

There are a few minor slips, such as 1799 for 1798 when Jenner introduced vaccination (p. 58), Withington for Withering, the discoverer of digitalis (p. 59), and 1947 for 1937 (p. 78, note 21). These corrections, however, in no way reflect on the accuracy and reliability of an excellent book.

GENEVIEVE MILLER *

United States Clock and Watch Patents, 1790-1890. By George H. Eckhardt. New York: Privately printed, 1960. Pp. xii, 231. 11 Illustrations. $10.

For the first time and in a single volume the author presents an annotated list of all patents relating to clocks and watches which have been issued by the United States Patent Office from its establishment in 1790 to and including 1890. The work is introduced by a very brief history of the Patent Office and specifications of the several Patent Acts.

The list of patents is divided into three major sections, namely, Clock, Watch, and Design Patents. The data provided for each patent listed include the title, name, and residence of the inventor, date of

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issue, and patent number. Each of the three categories is again subdivided. The subdivisions under Clock Patents, for instance, range from Clocks (General), Alarm Clocks, Astronomical Clocks, Clock Escapements to Clock Cases, Clock Stand, etc., with numerous headings devoted to various aspects of Electric Clocks. The numerous subdivisions under Watch Patents include the standard types such as Stem-Winding, Self-Winding Watches, Stop Watches, Watch Cases and parts, chains, keys, machinery and tools, and include even patents for the cleaning of watches.

The third section of the list is devoted to Clock and Watch Design Patents. Under the Patent Act of 29 August 1842, designs became patentable, and the Act specified that ". . . any person, who, by his own industry, genius, efforts and expense, has invented any new and original design became entitled to a Design Patent." A special system of numbering established for Design Patents is not to be confused with the standard numbering system for other patents issued by the Patent Office.

A chapter relates to clock and watch patents which appeared in the pages of the Journal of the Franklin Institute from 1826 to 1836. A summary of patents described in the Franklin Journal is furnished, and several of the patents are reproduced.

A few clock and watch patents of historical importance are reproduced in their entirety, including among others the 1841 patent to Aaron D. Crane for the rotary pendlum, the 1845 patent to Joseph Ives for the wagon spring principle of motivation of clocks, and the 1865 patent to Don J. Mozart for calendar clock improvement.

Eckhardt's list includes all patents issued to persons in foreign countries by the U. S. Patent Office for inventions and improvements of clocks and watches. Another noteworthy feature is a listing of sixteen patents issued for the invention of new types or improvements of sundials.

This book is a delight to the collector of clocks and watches, serving as a guide to the documentation of new items acquired and providing an easy reference for dating and identifying time pieces. At the same time it widens the collector's horizons for seeking out clocks and watches worthy of acquisition for some specific unusual or intriguing mechanical or other feature described in the patent. The book is a valuable source for those engaged in research in the fields of horological and/or technological history.

Despite its acknowledged usefulness, *Clock And Watch Patents* has a few shortcomings. The author states in a note that it would be impossible to index every name and item, and the reader is encouraged to peruse the book page by page for enjoyment and profit. Although this advice would benefit the casual collector with, literally, time on his hands, it would not apply to the scholar engaged in serious research.

The abbreviated list of major patent categories which is included as an index is scarcely adequate. A complete index of names and items would not only have been feasible, but would have added immeasurably to the value of the book. A descriptive phrase added to each patent listing would have further improved the project, providing easier identification.

Yet, in spite of the lack of the two improvements suggested, Mr. Eckhardt's book provides a very useful reference work in an area of research where one has long been needed, and the value of *Clock and Watch Patents* will become increasingly evident in time.

SILVIO A. BEDINI *

Shop Records of Daniel Burnap, Clockmaker. By Penrose R. Hoopes. Hartford: Connecticut Historical Society, 1958. Pp. viii, 188. Drawings and Plates. Limited edition. $10.

Relatively little has been published about American makers of scientific instruments and related crafts, an area of study greatly in need of exploration. The publication of Burnap's shop records is an important contribution to the field, providing the most complete account available to date of an important eighteenth century craftsman and his work. These records are particularly valuable because Burnap was equally skilled and successful in several fields of endeavor. He was a clockmaker, silversmith, instrument maker, and watch repairer. The life and work of Daniel Burnap (1759-1838), Connecticut clockmaker, were representative of the class of small, independent artisans whose working methods led to the development of modern industry in America.

After serving the customary apprenticeship with the well-known English-born clockmaker, Thomas Harland of Norwich, Conn., Burnap continued to work as a journeyman in his master's shop until 1786. Then he established his own business in East Windsor, producing clocks, surveying instruments, gold beads, silver spoons, chains, buttons, and ear-rings, as well as items in other materials.

Burnap opened his own shop at a most favorable time. Importation of clocks, brass goods, and instruments from England had ceased with the Revolution. The dwindling market in timepieces had forced most New England clockmakers to turn to other pursuits during the war years and the period following, and there was a minimum of compe-

* Mr. Bedini, of Ridgefield, Conn., has written many scholarly articles on the history of clocks.

tition for a man of as many skills as Burnap. With the advantage of his fine training with Harland, and a good location for his new shop, Burnap prospered.

During the years that followed he had a number of apprentices, several of whom went on to achieve fame in their own right. Outstanding among these were Eli Terry, Levi Pitkin, and Lewis Curtis. Although clockmaking was the most important phase of his work, Burnap did considerable watchmaking and repairing, and he produced hardware, brass goods, and jewelry. As the close of the century neared, Burnap looked to new fields of endeavor. He eventually sold his home and moved to Coventry, where he built and operated a sawmill. Later he established a still which he operated for a short time. In his later years at Coventry, Burnap became quite active in town affairs, and served in such various capacities as tax assessor, tax collector, surveyor of highways, and Justice of the Peace.

Several years ago the account books and business records of Daniel Burnap were acquired by the Connecticut Historical Society, and more recently his Memorandum Book was added to the collection, as well as the major part of the clockmaking and silversmithing tools from his shop. When the Society decided to produce a book based on these items, Penrose R. Hoopes, author of *Connecticut Clockmakers of the 18th Century*, was selected to write it. The successful result reflects Hoopes' considerable knowledge and understanding of his field. The author endeavored to bring forth every phase of the wealth of material in these manuscript sources.

For instance, the Memorandum Book was begun by Burnap when he started his apprenticeship with Harland, and he studiously noted the details and receipts of his craft as he learned them from his master. Here are to be found instructions for making chime and tower clocks, for engraving dials, designing, casting, and finishing clock wheels for calendar and moon phase attachments. Included are directions for casting bell metal, for regulating a watch, for silvering, and for case hardening, as well as countless other trade secrets practiced in his time by the independent artisan. This treasury is amplified by numerous drawings for laying out clock trains and for constructing a clockmaker's engine.

But this is but one aspect of the records. Burnap's daybook entries and ledger accounts mirrored the manner of transacting business in that era, revealing the employment of long-term credit as well as the extensive use of notes and bartering of merchandise, as a result of the scarcity of cash. The disposition of his own products was but a small part of a craftman's commercial enterprise, for he needed to be familiar with values and prices of many commodities which came his way in trade. Burnap solved the complicated merchandising problem by establishing his own little store expressly for the purpose of retailing

miscellaneous merchandise he acquired in the disposition of his own products and services.

Of considerable technological interest are the several sections of the book which relate to the production of clocks, scientific instruments, and hardware. Burnap was probably one of the more prolific of the Connecticut clockmakers prior to the introduction of mass-produced wooden clocks by his former apprentice, Eli Terry. In a span of two decades his journals listed payment for 51 clocks and 13 separate dials, a total of £667-5-0. This was not the total output of the shop for the period, however, for there is evidence of the production of a number of other clocks not recorded in the account payments, presumably paid for in cash.

Burnap was one of the American pioneers in the production of scientific instruments. These were limited to surveyors' compasses in brass as well as in wood, chains, and protractors. None of his compasses appears to have survived.

One aspect of the records which is of great importance relates to Burnap's shop methods and equipment. Many of his tools were made by hand from whatever scrap materials were available. Fortunately a large part of his tools and equipment have survived, and merely a listing of these provides a useful record of the working methods of the eighteenth century clockmaker and silversmith.

The general needs of a small New England community are fairly apparent from a perusal of Burnap's records of his products and services. Within a short interval he might be required to produce such varied items as brasses for a sword, hooks and eyes, silver tea and table spoons, hog rings, brass buckles, trimming for a desk, a hatpin, a brass clock, and the butts and nails for a coffin, while during the same period his services might be required for mending such necessities as flasks, andirons, a pistol lock, and perhaps a steel trap.

Numerous drawings and photographic reproductions illustrate the volume, which is tastefully produced in a manner worthy of the fine craftsman it is written about.

SILVIO A. BEDINI

A Guide to American Trade Catalogs, 1744-1900. By Lawrence B. Romaine. New York: R. R. Bowker Co., 1960. Pp. xxiii, 422. $15.

The best review of this book is contained in its Foreword, by A. Hyatt Mayor, Curator of Prints, Metropolitan Museum of Art. The only addition which needs be made to Mr. Mayor's comments is to point out that what he says regarding the value of Mr. Romaine's

invaluable compilation to historians of business applies with equal force to historians of technology. Herewith, Mr. Mayor's Foreword:

For several centuries historians have been moving steadily away from the ancient bare chronicles of battles and reigns in order to explore fresh approaches to man's past. Ever since the 1540's when Vasari discovered the history of art—or at least the history of artists—ever since Voltaire found that ideas have a parentage like people, historians have roamed around for new viewpoints from which to look toward the central subject of man. Thus the history of science has taken shape in the last couple of decades, and now the history of business is beginning to emerge.

The new historians of business will find a basic tool in Mr. Romaine's bibliography of American catalogues, for it is the first general listing of these scarce ephemera in any country. Like any pioneer survey, its structure will always endure under the additions that the years must inevitably bring. Henceforth no American trade catalogue can be listed respectably without a Romaine reference, or boasting (while perhaps adding a penny to the price) "Not in Romaine."

The United States has probably issued more business catalogues than any other country. We were by no means the first to do so, for by the 1780's the metal manufacturers of Birmingham and Sheffield were already sending out elaborately illustrated brochures to their agents in France, Italy, Spain, the Americas, and very probably India and Russia. These early British catalogues usually omit the name of the manufacturer lest the customer circumvent the agent by ordering direct from England. American catalogues much more often state the manufacturer's address so as to solicit direct orders from the customer, because in the United States money and goods could travel over great distances to vast markets without needing agents to negotiate barriers of exchange and customs' duties. The American opportunity for direct sales produced a fascinating profusion of small, inexpensive catalogues that vividly picture the epic of muscle, thought, and enterprise which built up our commerce, and dominated our history.

The lavish illustrations in catalogues of every country constitute the main historical source for the development of nineteenth century ornamental design. For previous centuries the record of design lies in the sets of prints published in great artistic centers in order to supply ideas when gentlemen were conferring with local craftsmen to create elegant and individual household furnishings. But when craftsmen's shops gave way to big factories in the world's progression toward larger and larger unities, the old design books gave way to commercial catalogues. So the history of nineteenth century design cannot really be written until foreign scholars imitate Mr. Romaine by compiling the bibliographies of the commercial catalogues of other countries.

Some time ago a number of far-sighted collectors became aware that such catalogues, while mere curiosities when gathering dust by twos and threes, become history—history with the fascination of anecdote and image—when they are arranged by thousands. This present Guide would have been impossible without the pioneer enthusiasm of a few librarians, collectors, and dealers who preserved what everybody else was clearing out and throwing away.

M. K.

The Electric Interurban Railways in America. By George W. Hilton and John F. Due. Stanford: Stanford University Press, 1960. Pp. ix, 463. Illustrations. $9.50.

George W. Hilton and John F. Due have made a significant contribution to a relatively neglected phase of American economic and social history that was associated with the rise and decline of the interurban railways in the United States and Canada. It is a book that should appeal to a wide variety of readers: from those with an antiquarian interest in descriptions of rolling stock, track layouts, speeds, routes, and the like, to individuals more concerned with a careful evaluation of the basic forces affecting the evolution of the interurbans.

The organization of the volume is especially noteworthy. Part One, divided into eight chapters, analyzes the industry as a whole, with particular reference to the effect of such factors as technology, finances, volumes of freight and passenger traffic, and governmental regulation on the promotion and operation of the interurban lines. In Part Two, the authors present brief historical accounts of some 400 individual lines that were built and operated in the United States and Canada.

The interurbans emerged about 1900 to meet the demand for a more flexible system of transportation than could, or was being provided by steam railways. By 1912, the network of interurban lines had approximately reached its final shape; but following the end of World War I, the industry began to decline, and by the 1930's, the interurbans had virtually disappeared, primarily because of their inability to compete effectively with the even greater transportation flexibility provided by passenger automobiles, trucks, and buses.

Students of the history of technology will be particularly interested in the account of how the interurbans adopted and adapted techniques developed earlier by the electric street railways and steam roads to meet their particular requirements. No less interesting is the explanation of how the failure to push further technological innovation contributed to the subsequent decline of the interurbans. While specialists

may find fault with the treatment of particular topics, it is difficult for this reviewer at least to suggest how the authors could have improved on the organization of their material or maintained a better balance in analyzing the complex of forces that effected the evolution of the interurbans.

HAROLD F. WILLIAMSON *

Energy in the American Economy, 1850-1975: An Economic Study of its History and Prospects. By Sam H. Schurr and Bruce C. Netschert. Baltimore: The Johns Hopkins Press, 1960. Pp. xxii, 774. 120 Tables. 73 Figures. $12.50.

This book represents a monumental effort to set forth information on the consumption and availability of the various fossil fuels and hydro-electricity in the United States. The period 1850-1955 is examined in great detail, and the analysis is then used as a framework for computing estimates of energy consumption and availability in 1975, based on certain assumptions concerning price. The author's principal conclusion is as follows: "Viewed strictly from the standpoint of its natural resource position and with due allowance for technological advance, the United States in 1975 or thereabouts could satisfy its demands for all energy, and for each of the energy materials of which the total is composed, from domestic sources of supply at no significant increases in costs, except for those which might be brought about by a rise in the general price level."

The book is divided into three main parts, together with appendices numbering 263 pages.

Part I consists of a presentation of total energy consumption, by types of fuels, for the period 1850-1955. A very detailed picture is given of the development of coal, petroleum, and natural gas during the period in question. This is followed by an examination of trends in total energy consumption, expressed on a per capita basis and per unit of Gross National Product. In this connection, the conclusion is reached that average annual rates of increase, according to five year intervals, for both total energy consumption and per capita energy consumption have not exhibited any degree of uniformity.

Part II contains the projections of energy consumption to 1975. In brief, it is suggested that the consumption of coal will increase from 451 million tons in 1955 to 768 million tons in 1975. In the

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case of petroleum, an increase is foreseen from 2774 million barrels in 1955 to 5154 million barrels in 1975. Natural gas is expected to show an increase in consumption during the period from 9614 to 19,881 trillion cubic feet. On the basis of a per cent of total energy consumption, coal exhibits a decline from 28.8 per cent in 1955 to 25.5 per cent in 1975. The change that is visualized in the relative importance of natural gas is from 24.0 per cent in 1955 to 26.5 per cent in 1975. The anticipated contribution from petroleum remains virtually unchanged. This section also comprises a detailed projection of energy consumption by types of energy, according to major end uses. Separate consideration is given to industrial, commercial, household, transportation, government, agricultural, and miscellaneous uses. Again, from a per cent of total standpoint, the principal shifts in relative importance involve a decrease in the household sector from 18.8 per cent in 1955 to 16.9 per cent in 1975. Conversely, an increase in the role of transportation is forecast from 20.2 per cent in 1955 to 23.7 per cent in 1975.

No provision is made for the inclusion of estimates of the contribution from nuclear energy in the forecast year. The authors observe that uncertainties surrounding the timing of its development are so great that there is little more than conjecture to go on. Concerning the possible future of nuclear power, the opinion is advanced that when its use becomes important the principal impact will be on coal because of its increasing dependence on the electric utility market. According to the authors, the most reasonable guess is that nuclear energy might supply 10-15 per cent of total electrictiy production by 1975. If the full impact fell upon coal, this could result in a loss of market, ranging from 75 to 110 million tons. On this basis they believe that: "Coal may begin to feel significant effects by 1975 and far greater effects in the years following." Before concluding my remarks on this part of the book it is perhaps pertinent to note that although repeated references are made to estimated energy consumption in 1975, the introduction to Part III contains the following qualification: "A basic assumption in estimating future energy consumption was the continuation of 1955 price interrelationships in the period through 1975. Thus the resultant estimate is not a forecast of 'demand' in 1975 in the sense of specific quantities that will actually be taken up by economic activity in that year."

In the introduction to this third section—which is concerned with energy resources—the authors go on to observe: "Similarly the estimates on the supply side . . . are based on special circumstances which means that they do not constitute forecasts or predictions of what actually will be produced in 1975, hence the term supply should not be applied to them. . . . The term availability is used to describe the resultant estimates. It may be defined as what could be produced or

made available in the year in question, at no appreciable increase in constant dollar costs." Prior to launching into an evaluation of this question, the authors point out that there is a need for a new terminology on reserves. A threefold classification is suggested, which, briefly defined, is as follows:

(1) Reserves—stocks of mineral raw material in place as viewed by the producer;

(2) Resource base—the sum total of a mineral raw material present in the earth's crust within a given geographic area, regardless of cost;

(3) Resources—that part of the resource base (including reserves) which seem likely to become available given certain technologic and economic conditions.

Although a new terminology is advocated, it should be noted that the authors explicitly point out that "information about natural resources and technology is basic to our analysis of the supply prospects for 1975, but the development of new information on either resources or technology was beyond the capacity of this study. Hence, it was necessary to rely on existing information on both subjects. What is new is the framework within which the information was analyzed."

On the basis of these assumptions, almost the entirety of Part III is devoted to a comprehensive examination of the future resource position of coal, petroleum, natural gas, and hydro-power. The total future availability of petroleum is placed at 500 billion barrels and a figure of 6 billion barrels is suggested as probable for 1975. In the case of natural gas, the corresponding figures are 1200 and 22.5 trillion cubic feet. Comparable figures were not developed for coal since it was felt that the resources are so vast that there can be no question about availability in terms of foreseeable demand.

In the 12 years that this reviewer has been following the subject of energy supply and demand, nothing has been published that approaches the comprehensive treatment of this matter in the U. S. by Mssrs. Schurr and Netschert. I believe there is no question but that this book will serve as a point of departure for other studies of this nature for quite some time. The very detailed statistical appendices (some 250 pages) bring together a great deal of information on the subject of energy consumption-past and possible future. In addition, source material is copiously noted so that those who wish may refer to the original works.

B. C. THOMPSON *

* Formerly with the Socony-Mobil Oil Co., Mr. Thompson is an economist and sociologist who specializes in the analysis of future energy requirements in terms of technological change.

The Development of the English Traction Engine. By Ronald H. Clark. Norwich, Eng.: Goose and Sons, Ltd., 1960. Pp. 388. 84s.

This volume will be valuable to the historian-engineer for its detailed and encyclopedic treatment of the English traction engine. A great many of the engine details and dimensions are given here for the first time, and the author has been sedulous in consulting makers' original drawings and in following the successes and vicissitudes that attended the businesses of the famous firms who formerly made traction engines in England.

Traction engines have a robust nature that has led to many of them being preserved for occasional steaming at rallies held by the two English traction engine preservation societies. Mr. Clark knows these engines well and has traced the fate of many others, some of which were exported to far distant lands. He is equally interested in the stables from which they came, and elaborates with chatty incident. There are 582 illustrations, ranging from Hancock's "Tug," an early road engine for a customer in Vienna, through chain driven and early geared engines to the later period of 1880-1905, during which years the business became stabilized, while the engines were compounded and mounted on springs. In this their heyday they were used for many purposes—agriculture, road traction (2-4 miles per hour), and generation of electricity, while France used them in 1860 for steam rollers, followed later by England. After 1905 there was a decline, and few were made after 1914.

For most of the engines the author gives tables of essential dimensions including bore, stroke, and number of cylinders, the heating surface and grate area of the boilers, speed of revolution of the engine, steam pressure, road speed, gear ratios, and B. H. P. It will surprise some readers to learn that the horse power was comparatively small, many being 8-10 H. P. In the chapter on testing, indicator diagrams are given and the results of tests by Professor W. E. Dalby in 1900 and others suggested by Professor B. Hopkinson in 1911, including brake tests with the driving wheels set off the ground and the modern type dynamometer rig used for testing tractors today.

The drawings of valve gears, linkages, and gear trains are excellent. Another useful feature is the description and diagrams of the cable system of ploughing in vogue around 1900.

Besides illustrations and specifications, there are details of running costs and tests for various engines. Calculations for design of components, etc. are omitted as the author thinks this is matter for standard texts. In a less serious vein, one chapter is called "Odds and Ends," which includes accidents and anecdotes, references to steam in world literature, from Jules Verne to *Punch*, with some nameplate and letter heading facsimiles from famous firms for good measure.

This book has the same all embracing, endearing, and sometimes

irrelevant and superficial quality as an enthusiastic schoolboy's collection often has. Its place is with the reference books, but its value is much impaired by the inadequacy of the Index; also, the illustrations are in some cases not dated. Nevertheless, the wealth of data makes it indispensable for the student of the subject, and the illustrations are of a remarkably high standard. The style in which the book is written brings back nostalgically the atmosphere that surrounded the engineers who worked in this field of crude engineering.

AUBREY F. BURSTALL *

Monopoly on Wheels: Henry Ford and the Selden Automobile Patent. By William Greenleaf. Detroit: Wayne State University Press, 1961. Pp. xii, 302. $5.95.

The Selden patent controversy provides one of the most fascinating, and at the same time one of the most confusing, episodes in the history of the American automobile as the one attempt made to assert a comprehensive patent claim covering the gasoline automobile. Much of the confusion has now been removed, in terms of establishing and clarifying the facts as to who George B. Selden was, what he did, and how the famous Selden patent suit was fought out. Dr. Greenleaf's research has been exhaustive on these points; the material he has produced is impressive.

He has clearly demonstrated the significance of the Selden case in the development of American patent law. It revealed some glaring weaknesses in the patent system and in the judicial handling of patent suits and resulted in some remedial steps being taken. It also was of far-reaching importance in the development of the American automobile industry, in that it convinced the participants of the futility and danger of constant patent litigation and resulted in the quite unique system of free cross-licensing of patents which the industry adopted in 1915 and kept in force until 1956.

From the point of view of the historian of technology, Dr. Greenleaf has made a valuable contribution in his detailed description of the evolution of the internal combustion engine, and in particular of the two-cycle, constant pressure engine designed by George B. Brayton in 1872 which Selden tried to adapt for his proposed road vehicle. He has also clarified the modifications which Selden made in the wording of his claim during the sixteen years it lay in the Patent Office.

* Dr. Burstall is Professor of Mechanical Engineering and Director of the Stephenson Engineering Laboratories, King's College, University of Durham, Newcastle upon Tyne. He is writing a *History of Mechanical Engineering* which will shortly be published.

There is ample justification in economic, technological, and legal history for a scholarly study of Selden and his patent. It is unfortunate that the author felt that he had to reach farther for dramatic effect by presenting the patent suit as a contest between monopoly and free enterprise. We can concede that William C. Whitney and the Electric Vehicle group had monopolistic ambitions, but Whitney died in 1904 and the Electric Vehicle Company lost control of the Selden patent when the Association of Licensed Automobile Manufacturers was formed in 1903. We can also grant that some members of the A. L. A. M. wanted to use the patent to restrict competition; that they were opposed to the development of a cheap car requires more proof.

Nevertheless, intent and execution are not identical, and the facts of this situation are that the A. L. A. M. never came close to restricting competition. If any manufacturer was forced out of the automobile industry or prevented from entering it by the A. L. A. M., Dr. Greenleaf has failed to record the fact, and one would assume that he would be anxious to include as much evidence in support of his thesis as he could find. There is, indeed, a flat contradiction on this point in the book. On page 173 the author says, "the threat of the Selden patent deterred many investors from entering the industry"; but on page 237, "It has also been held that the Selden patent shackled investment, production and technological innovation in the industry as a whole. Such claims have no foundation in fact."

It is not even certain that the contemporary public attitude toward the case, which applied the analogy of David and Goliath with Henry Ford cast as the hero, was accurate. Dr. Greenleaf states that in 1903, when the suit against Ford was initiated, the independents had *estimated* resources of $27,000,000 against $70,000,000 in *nominal* capital for the licensed manufacturers. The italics are mine. This is hardly an adequate basis for evaluating strength, particularly since the author has previously made it clear that the Electric Vehicle Company was in a very unhealthy condition. By 1908, before any verdict had been reached, the four leading producers of passenger automobiles were Ford, Reo, Maxwell-Briscoe, and Buick; only Buick belonged to the A. L. A. M. and it had discontinued royalty payments.

The book, indeed, should have an additional subtitle: "The Case for the Defense." In analyzing an issue as vital and controversial as the Selden patent case, the historian has both a need and an obligation to pass judgment, but he is still expected to present the evidence itself as dispassionately as he can. Dr. Greenleaf has some lapses in this regard. He needs to give more substantial authority than his own bias for belittling Judge Hough, who ruled against Ford in the District Court, and extolling Judge Noyes, who gave the decision of the Circuit Court of Appeals. He has also overlooked or ignored some adverse evidence. For instance, he claims (p. 212) that Ford refused

to compromise with the A. L. A. M. after the district court decision. Ford was offered a membership without payment of back royalties and came close to accepting, but finally declined when the Association refused to pay his legal expenses. This information came from Alfred Reeves and is in print and available.

In his discussion of the technical features of the case, the author makes much of the poor performance of the cars built by Selden and Henry Cave to demonstrate that vehicles built to the patent specifications would run, and suggests further that they deviated from the patent in important respects. Had he consulted Henry Cave (I did in 1956 and have corresponded with him since) he would have been assured that the car Cave built contained nothing which was not available in 1879 and was an operable vehicle. Its poor performance is hardly relevant; one might as well reject the Kitty Hawk flight of the Wright Brothers on the ground that it lasted only 12 seconds.

These are admittedly details, perhaps minor. Dr. Greenleaf's sympathy for Ford is understandable, and, if due allowance is made for it, he has given us a useful and lucid account of an important event in automotive history.

JOHN B. RAE *

The Tale of the Comet: The Story of the British Jet Airliner. By Derek D. Dempster. New York: David McKay, 1960. Pp. 218. Illustrations. $4.

One of today's most highly regarded jet-propelled aircraft is the de Havilland Comet 4. Mr. Dempster's book recounts the development of this design, with particular attention to the remarkable investigation at Farnborough that cleared up the mystery of two serious accidents and pointed the way to major advances in the art of airplane design.

In January, 1952, a Comet 1 carrying 29 passengers exploded in the air near Elba, soon after leaving Rome for London. A few weeks later, another Comet 1 left Rome for Cairo and was not seen again, but the bodies of some of its 14 passengers were found floating on the waters of the Bay of Naples. These disasters were enormously disturbing to aeronautical engineers: the Comet 1 was the first of the very fast jet-powered designs to go into commercial service, and it was well-known that it had been subjected to much more extensive tests than usual before it had been granted a certificate of airworthiness. Since there was no survivors and no competent witnesses of either

* Dr. Rae is Professor of History, Harvey Mudd College and author of *American Automobile Manufacturers, The First Forty Years.* In 1960 he received the Thomas McKean Memorial Award for research in automotive history.

crash, and the wreckage was on the floor of the Mediterranean Sea, it was feared that the causes of the crashes might never be known with any certainty and that the progress of civil aviation would be seriously hindered.

The British government and public were specially disturbed, and Sir Winston Churchill promptly authorized a thorough investigation to discover, if at all possible, what had happened and why. This assignment was carried out by the Royal Aircraft Establishment at Farnborough under the direction of Sir Arnold Hall. The British Navy concurrently overcame great obstacles in locating and retrieving a large part of the wreckage of the plane that had come down near Elba and rested under about 500 feet of water. The recovered pieces proved to be of enormous assistance to the Farnborough engineers, who were thoroughly examining every plausible theory and dismissing none until it had been definitely proved inadmissible.

One by one every suggested cause was thus eliminated until the only one left was metal fatigue. This had originally been considered highly improbable, since the service lives of the lost airplanes (less than two years) had been only a small fraction of that indicated by the fatigue tests to which the design had been subjected by de Havilland. At Farnborough a complete fuselage cabin was tested in a specially built tank, and methods were devised to make the tests simulate actual flight conditions far more closely than had previously been considered possible. The fatigue life of the test cabin was so close to those of the lost airplanes that the engineers were confident that the problem had been solved. They were convinced of this when pieces of the cabin roof retrieved from the sea near Elba showed definite evidence of fatigue failure just where the Farnborough tests indicated it should be. Similar tests of a subsequently designed Comet 4 fuselage indicated a life of over 354,000 flying hours (or over 118 years) of service. Thus these tests not only solved the problem of what had happened but also pointed the way to avoid repetitions of the failures. The crashes were transformed from mysterious and frightening " Acts of God " into landmarks in the development of engineering knowledge. Present day jet aircraft are unquestionably much safer as a result of the Farnborough studies and the unfortunate accidents that triggered them.

The whole story is told in *The Tale of the Comet* by Derek D. Dempster, a former flight test pilot, who had known and interviewed many of the people involved. He starts with the entry into aviation of Sir Geoffrey de Havilland in 1908 and concludes with the resumption of airline service by a new generation of Comets fifty years later. He first recounts the development of the earlier de Havilland designs, such as the BE 1 of World War I, the DH 4 so much used in this country in the 1920's, the popular Moth light plane of the thirties for

private pilots, and the Mosquito bomber of World War II. Most of the book, however, is devoted to the Comets which Sir Geoffrey de Havilland hoped would restore the prestige of Great Britain in aviation by initiating the commercial use of jet propulsion.

Mr. Dempster's book does not go deeply into technical detail, being written for the layman in a pleasant journalistic style. One result is that it is difficult to locate some dates and other specific statements which a historian might wish to check. In fact the usual paraphernalia of scholarly writing are almost completely lacking. There is no index, and not a single footnote in the book. There is a bibliography, but it lists only half a dozen books and the files of three periodicals. Nevertheless, Mr. Dempster has produced an absorbing and valuable narrative covering the life and work of one of the most able and productive of the world's airplane designers. He has much to tell of the personalities connected with the development and utilization of the Comets and their de Havilland predecessors, and also sheds much light on the amount of preparation required to develop a new air service or to introduce a new design in present day air transport. Although the central event of the story is a tragic accident, the story as a whole is reassuring, and a reader would feel no more qualms about boarding a Comet 4 on his next trip to London or Singapore than about driving along the freeway to get out to the airport.

ALFRED S. NILES *

Big Eight: A Biography of an Airplane. By Richard G. Hubler. New York: Duell, Sloan and Pearce, 1960. Pp. xiv, 244. Illustrations. $5.

Richard G. Hubler, a veteran aviation-writer of both non-fiction and fiction, centers attention in this book on the Douglas Aircraft Company's contribution to the "jet age" in commercial air travel. The "Big Eight," better known to millions of travelers as the DC-8, is presented as a thoroughbred of distinguished lineage dating from the early 1930's when the first of a series of transports bearing the initials for "Douglas Commercial" rolled from an assembly line in Santa Monica, California. The Douglas jet was flight-tested for the first time on May 30, 1958, and commenced regular service on the airways in the late summer of 1959 in competition with the older Boeing 707 and British-built Comet 4.

* Professor Emeritus of Aeronautical Engineering at Stanford University, Mr. Niles was at one time Chief of the Structures Unit, Materiel Division, of the U.S. Army Air Corps. He is the co-author, with J. S. Newell, of *Airplane Structures*, and is a Fellow of the Royal Aeronautical Society of Great Britain and of the Institute of Aeronautical Sciences.

Big Eight reveals the various steps in the evolution of the Douglas jet transport from a vague almost elusive idea hatched shortly after World War II, through the formation of a special projects office in 1952 to prepare the plans, through the construction and testing of components, to the flight test of the first of the finished products. The subtitle, "A Biography of an Airplane," is misleading since no mention is made of the transport in commercial operations, nor is the book exclusively about a single type of aircraft.

It is also the story of Donald Wills Douglas and the company he founded in 1921 with $600 in capital, a talent for design and construction, and an unshakable faith in the future of aviation. About one third of the book is devoted to the man, the company, and the amazingly dependable aircraft which, in forty years, have appeared as seventy-eight legitimate descendents in the famous Douglas lines.

Hubler's book is an important addition to the growing volume of literature about the American aircraft industry. Harold Mansfield's *Vision: A Saga of the Sky* (New York, 1956) and Martin Caidin's *Boeing 707* (New York, 1959) provide excellent studies of the Boeing Airplane Company, including its contributions to jet-powered military and commercial craft. With the publication of *Big Eight*, and the recent appearance of Carroll V. Glines, Jr., and Wendell S. Moseley's *Grand Old Lady; Story of the DC-3* (Cleveland, 1959), students of the history and technology of aviation have a convenient and accurate record of another important manufacturer, as well as a step-by-step account of the method by which a new and revolutionary airplane came into being. There remains a need for similar studies of other prominent builders, past and present.

The DC-8 occupied a unique position in American aviation, according to Hubler, because it was a gigantic risk to maintain the Douglas company's supremacy in the transport field. The decision to make the costly change from piston-engines to jets was, both for the manufacturer and the air line operators, based on the knowledge that traditional power systems were approaching a point where they could not offer greater size and speed without an alarming sacrifice in safety and economy of operation. Boeing, with experience and financial aid acquired from government contracts for bombers and the KC-135 tanker, shifted to jet-powered transports with comparative ease and relatively little expense. Douglas had to cope with almost insurmountable problems of engineering and finance to produce an entirely new type of airplane.

Using vast resources and experience acquired over a period of nearly four decades, the Douglas company designed and built the DC-8 in six years. Hubler calls the expenditure of $500,000,000 in this project "The largest single venture of its kind on a single product in the world." The result "may be the finest expression of the airplane that

operates in the air," and probably the last subsonic craft to travel within the limits of the earth's atmosphere.

The praise which the author heaps upon the Douglas jet transport is understandable but hardly defensible when the DC-8 is said to be far superior to any other craft of its type in operation today. In the neverending struggle to design and construct technically superior airplanes for the commercial air transport industry, Douglas, although invariably second in the point of time, had gained the lion's share of business because he was consistently first in quality. In the past three decades his DC-3, 4, and 6 overcame, in turn, advantages of the Boeing 247-D, 307, and 377. In the year and a half that both Douglas and Boeing jets have been in competition on the airways there has been no clear indication that Douglas will again score a victory over his principal rival.

HOWARD L. SCAMEHORN *

Industrial Estates: Tool for Industrialization. By William Bredo. International Industrial Development Center of Stanford Research Institute. Glencoe, Ill.: The Free Press, 1960. Pp. xvii, 240. 44 Illustrations. 11 Tables. $6.

How can backward nations quickly increase productivity without communistic compulsion? The book *Industrial Estates* reports a technique whereby the logistic talents and eminent powers of government, or of large private capital, enlist small entrepreneurs' profit motivation. From England's 1899 pioneer effort at Trafford Park to World War II, the formation of industrial estates (sometimes called parks or districts) averaged only one per year; but since then they have been appearing 28 times as fast.

This study by economist William Bredo appears to be the first full-length description of the international phenomenon of tracts preplanned to accommodate multiple independent manufacturers. The author distinguishes three degrees of prepackaging: (1) Merely improved land—an industrial tract. (2) Land plus market-researched buildings—an industrial subdivision or cluster. (3) Land plus buildings plus central services—a fully packaged estate, whose cost may be 100 times that of the tract.

Industries prefer estates because in them capital, building, utilities, labor, and expertise are more economically unified (546 acres is the American average). Rambunctious youthful industries require estate

* Assistant Professor of History at the University of Colorado, Dr. Scamehorn formerly served as research editor for the Illinois Department of Aeronautics. He is the author of *Balloons to Jets: A Century of Aeronautics in Illinois, 1855-1955.*

flexibility; thus, the Vancouver (Canada) district offers 3,000 square foot "Nursery Factories" whose partitions can be razed to accommodate growing tenants without relocation. The more fully packaged the estate, the wider its services: a pressure die-casting shop in Madras, India; electronic cost-accounting in Westbury, New York; a heliport in Vancouver. So the tenant industrialist specializes in factory management, surrendering external relations to the estate administrator.

Another beneficiary is the community. It often fosters estates to offset agricultural decline—as in Puerto Rico, where Operation Bootstrap has sired 500 firms, principally offshoots of American ownership. Catering especially to small entrepreneurs, the estate expressly or secondarily trains the managers and technicians who are so greatly needed in emerging nations. It raises employment, living standards, tidiness. Industrialization increases national sinew, leaders believe (although quantification of this claim is as lacking as for John K. Galbraith's counterclaim in *The Affluent Society*).

The management investigates the applicant's initiative and proposal rather than merely his wealth; the Glasgow park goes so far as to limit products to those that provably contribute to "national wealth." Estate siting utilizes neglected local resources (e. g., initially unprofitable stone at Delhi, India). It cordons noise, fumes, traffic. It decentralizes population; thus, Harlow New Town was separated by 23 Greenbelt miles from saturated London, and in a dozen years has grown to 80,000 inhabitants.

This new paternalism avoids the horrors that attended England's laissez-faire factory revolution. Workplaces swim in elbow room, air, and sunlight, if the photograph of those in Madras is typical. So the estate synthesizes socialistic planning and individualistic initiative.

Dr. Bredo's book provides especially complete detail for physical layout and costs. It arranges information by functions, sponsorship, preplanning, location, structures, facilities, and finance. The appendix selects 22 estates for two-page description. The volume therefore discusses individual parks in many locations and with extensive repetition. But the reader cannot link the various aspects of any selected estate, for there is no index.

A notable bibliography lists brochures from 15 countries and 87 books. (Since estates are developing so rapidly, the user would be wise also to consult associations, like the American Industrial Development Council, and periodicals, like *Industrial Development*.) Information hitherto marvelously widespread appears, then, as a chowder rather than a puree.

Surprising multiformity appears within every estate classification. Sponsorship ranges from private-for-profit (e. g., a Union Pacific Railroad subsidiary) to fully governmental (e. g., Pennsylvania Industrial Development Authority). Terms vary erratically; thus, Basil-

don (England), founded just a few years ago, will grant a lease for 999 years. Employees may be 10 (Valby, Denmark) or 1,000 (Gateshead, England).

The estate phenomenon, although defined as peculiar to small industry with its "lack of access to capital," consists largely of subsidiaries of excellently capitalized U. S. corporations in the case of Puerto Rico, the nation third richest in estates (pp. 178-9). Newly developing nations are said to have had "most successful demonstrations" of estates (p. xi); yet over half are in the most developed nation, our own, and none of the world's 573 estates is reported in fast-industralizing West Germany, Israel, or Japan. The time factor is equally baffling: these economizers are said to have expanded only slightly during the Great Depression, but flowered suddenly in the rather prosperous period following World War II.

Perhaps only Dr. Bredo's definition differentiates the estate from the common variety of land that is industrially zoned and taxed. Perhaps the growth of this form instead reflects the spirit of the times, the *Zeitgeist*.

A laissez-faire spirit pervades once cartelized lands like West Germany. At the same time, a collectivistic spirit increases at the extremes of the economic spectrum—underdeveloped nations like India and mature nations like America. Is it accidental that estate density is rather proportional to this collectivistic spirit? Is this not the era of James Burnham's managerial revolution, Adolf A. Berle Jr.'s capitalist revolution, William H. Whyte's organization man? Do we not sense a surging organizational idolization, akin to that of the Middle Ages, which would naturally foster the estate? Why otherwise would the Pakistani government expand its Hyderbad Estate even though it already suffers embarrassing electricity blackouts? The author wisely refrains from declaring the estate to be a democratizing force.

The industrial concept is undergoing a long-range expansion, for it is not merely a manufacturing process but a trend in human organization. When one superimposes this extension upon the corporate worship, he understands Dr. Bredo's factual observations far more than from economic grounds alone. For the estate is not an integrated entity; its management hedges against economic cycles by diversifying its tenants (p. 5). So this phenomenon resembles the commensalism we find in biology. And it need not produce a higher *species* than commensalism, which produces the lowly lichen. Estate growth may not be so much an index of efficiency as of ethos.

Productivity cannot be separated from ecology; the Hawthorne workers, one recalls, stubbornly *increased* output as management experimentally worsened lighting. So Dr. Bredo's study of a form allegedly designed to improve productivity creates a need for the measurement of its interplay with culture.

The volume's statistics are scanty—and most are accredited to T. K. Pasma's earlier, narrower book. Historical comparison is everywhere needed. For instance, has the Rotterdam estate, established after 80 per cent of the city's enterprises were found to employ under 11 workers, affected that number? By how much do estates cut costs? Are the economies transmitted as lower product prices and higher wages (the practice of Henry Ford)? Have park managements shared profits with their manufacturing tenants (as do some shopping centers)? How do the profits (13.9 per cent of gross revenue, for New York City's Bush Terminal) compare with those from non-estates? How effective has local development (in Nigeria, eight native companies in one year) proved in comparison with transplantation of hearty motherland corporations (in Puerto Rico, 500 in a decade)? What standard can measure U. S. Technical Cooperation Mission contributions (e. g., 36 machine tools to the Madras park)? What causes one nation, challenged by declining agriculture, to respond with estate inauguration (Britain, 81 districts) while a neighbor ignores them (France, 0)? Are medium-sized firms grouped into tracts in the unmentioned U. S. S. R.?

The contribution of William Bredo and his sponsors is, then, to have observed and defined the trend toward zoning and mothering of new industries. The book is an essential for supervisors who have *already* decided on an estate, at any level from federal bureau to local tenant. It is valuable principally as a compilation of information sources for personnel who would decide *whether* to establish an estate, and for those concerned with the interplay of work-organization and culture.

HENRY G. BURGER *

The Research Revolution. By Leonard S. Silk. New York: McGraw-Hill, 1960. Pp. x, 244. $4.95.

I strongly recommend this book to any technical man engaged in directing research and development in the United States. In his book, Dr. Silk furnishes a great deal of economic information which would be very helpful to anyone planning the future of his corporation, or of the country. A great deal of economic information contained in this book may be "old stuff" to the economist, but it is presented here in such a way that we of the technical group can understand it and put it to use. There are many facts in this book which would be

* A marketing tactician in New York City, Mr. Burger is a Lecturer in Marketing at the City College. In his articles, which have appeared in some fifty periodicals, he has paid particular attention to what he terms "panindustrialism," the universal applicability of industrial technique.

useful to the research investigator in arguing with the company's economist as to how the future should be planned.

Throughout the book, Dr. Silk points out why we must have a certain minimum increase in the GNP (gross national product) in order to make use of our rapidly growing population. For instance, on page 37 he states: "But if we don't succeed in getting anything better than a 2% growth rate annually, population increase will very likely gobble up practically all of the gains—and increases in productivity at anything like their recent rate will mean unpleasantly high and chronic unemployment."

From data of this type one learns that the author is very much concerned about finding sufficiently new and important areas to keep our population gainfully employed.

In his second chapter—"The Forces of Growth"—Dr. Silk argues for more research, partly on the basis that the products that were new in 1940 are now old and many of them are on the decline. As a case history to show what is needed in the way of new ideas, he cites the case of the transistor and develops it from its conception in 1948 to the present day, showing how this single development has offered many new opportunities for new businesses and new products. From this basis he then develops the idea that what is needed is more "brain power." Thus on page 112, he states: "The job of getting educated people in large enough numbers and of sufficiently high quality is one of the crucial jobs facing the nation." Dr. Silk seems to have the feeling that if we can get enough bright people working in a field we are certain to find developments equivalent to the transistor, simply on a statistical basis. I think this point of view is open to some question. We in research have a tendency to emphasize planning for the future.

The sixth chapter—"Can We Get Balanced Growth?"—makes a very good point for all of us in research to remember. It is well worth quoting: "We have defined growth as a long-run phenomenon. But—to quote Keynes' most famous dictum—in the long run we are all dead. Long-run growth without short-run stability isn't worth much; indeed, without stability, we might all be dead in the short run." To me this statement emphasizes the importance of a balanced research program; and while we need bright people for creative work, we also need many more people who can take these long-run gains and convert them into a short-run reality.

In this same chapter, Dr. Silk goes on to say: "There are strong reasons for thinking that we have reached a time when the American economy needs a boost of one sort or the other. For we have moved out of the postwar period into a new era in which, it now becomes increasingly clear, inflationary pressures have abated and growth is coming harder." The author believes that the economic growth needed to maintain and hold our position can only come about through research and a research revolution. He therefore argues that the

policy-makers should make certain "that the overwhelming emphasis of any program for growth must come to focus on technological progress, and the factors that promote it or obstruct it."

We can sum up the author's feeling about our contest with the Russians, and its importance to the United States, in a statement which he ascribes to his friend Herb Stein: "If the Soviets can give us such a bad time when their GNP is less than half of ours, think what we can do to them when our GNP is half as big as theirs."

Dr. Silk draws no conclusions as to how to effect these changes; he leaves it to the reader to consider the case and draw his own conclusions. I strongly recommend this book.

W. E. HANFORD *

Science and Education at the Crossroads: A View from the Laboratory. By Joseph W. Still. Washington, D. C.: Public Affairs Press, 1958. Pp. xii, 140. $3.75.

This is a vigorous, salty book pleading again for more understanding of science in government, education, and rather specifically, foreign affairs. Since most of the voices recently raised in this cause have been those of physical scientists or engineers, it is refreshing, and useful, to hear from a medical scientist. Dr. Still served in the Army Medical Corps during World War II and was deeply impressed by the victory of DDT over malaria and typhus. It is his view that this weapon, plus the others currently available to medical science, have made possible the enormous increase in human energy that now displays itself in the clamor of the underdeveloped areas of the world for a place in the twentieth century.

Dr. Still is quite aware of the awesome population problem, but it is his contention, as both scientist and humanist, that rational population control is possible only among healthy, literate people with a reasonably advanced standard of living. We must therefore pursue even more vigorously than we have in the past the somewhat paradoxical course of saving lives and increasing life expectancy, in the face of the population explosion. He cites figures from 1820 on, in both Europe and the New World, to show that over the long haul "industrialization carries its own built-in population controls." One can only hope that Dr. Still is right and Malthus was wrong.

The opening section of this book teems with suggestions for the internal organization of the scientific enterprise, for encouraging more and better basic research, and for finding and educating more of our

* Dr. Hanford is Vice-President for Research of the Olin Mathieson Chemical Corporation.

young people who ought to be entering scientific pursuits. "From what you read in the papers and magazines," he says, "you might conclude that the problem of getting scientists is something like catching mice in a trap. You set a trap, bait it with a little cheese, and wait. You assume that the mice are not as smart as you are. You often catch a mouse that way. The trouble is that the mice you catch by this technique are the stupid ones."

He is bitterly critical of the I. Q. worshippers, and charges that "segregation which puts the 'gifted' in special schools with the 'best' teachers is certainly a formula for making the competition of life turn out the way the I. Q. scores predict."

Taken as a whole, this is a volume which anyone interested in the place of science in our society will find stimulating and provocative. Serious scholars may think it not only unsystematic but even superficial in spots. They are hardly likely to find it boring. Recommended for rapid reading.

GEORGE A. GULLETTE *

*Dr. Gullette is head of the Department of Social Studies at North Carolina State College. He was Director of the Humanistic-Social Research Project of the American Society for Engineering Education which produced the volume *General Education in Engineering*.

Notes and Announcements

Dr. John Bell Rae, Professor of History, Harvey Mudd College, Claremont, California, has been given the Thomas McKean Memorial Award by the Antique Automobile Club of America, the nation's oldest and largest automotive historical society, in recognition of Rae's book, *American Automobile Manufacturers.*

The award was presented at the Society's annual meeting in Philadelphia, February 11. Mr. Charles A. S. Heinle, representing the Chilton Company, publishers of the book, received the award for Professor Rae.

The Thomas McKean Award is made for outstanding research in the automotive field. In citing Rae's contribution to automotive history, the Society said, "His work is the first astute analysis of automotive industrial management's relationship to technological change and industrial advance."

Dr. Rae has been a member of the Executive Council of the Society for the History of Technology since its inception and is an Advisory Editor of *Technology and Culture.*

* * *

Eight members of the Society for the History of Technology are among the sixteen American scientists, historians, sociologists, and philosophers awarded travel grants by the United States National Committee of the International Union of the History and Philosophy of Science (IUHPS) to attend the Symposium on the History of Science in Oxford, England, July 9-15. An Oxford committee, headed by A. C. Crombie of All Souls College, selected the individuals for the grants, and the National Science Foundation povided the funds for the travel of the American scholars. Those chosen included: I. Bernard Cohen (Harvard University), Henry Guerlac (Cornell University), A. R. Hall (U. C. L. A.), Thomas S. Kuhn (University of California, Berkeley), Everett Mendelsohn (Harvard University), Robert K. Merton (Columbia University), Richard H. Shryock (American Philosophical Society), and Lynn White, Jr. (U. C. L. A.)

The U. S. National Committee of the IUHPS is the agency for effecting American participation in international activities in the history and logic, methodology, and philosophy of science. It functions under the auspices of the National Academy of Sciences-National Research Council.

Officers of the Committee for 1961 are: Chairman, Dr. I. Bernard Cohen of Harvard University; Vice-Chairman, Dr. Alfred Tarski of

the University of California, Berkeley; Secretary, Dr. Melvin Kranzberg of Case Institute of Technology.

* * *

One of the greatest research art collections in the world on Leonardo da Vinci has been given to the University of California at Los Angeles by Dr. Elmer Belt, clinical professor of surgery at the UCLA Medical Center. Known as the Elmer Belt Library of Vinciana, the Library contains approximately 15,000 books, articles, and items, all catalogued according to the Library of Congress system. Included is a good share of the great fifteenth and sixteenth century source books which are documented as Leonardo's sources of learning.

The greatest treasures of the library, according to Dean Lawrence Clark Powell, head librarian at UCLA, are 56 books printed before 1501 (the "cradle books" of the art of printing) and about 175 books printed before 1650. In addition, the library contains the complete run of 65 editions of Leonardo's famous "Treatise on Painting," including printed editions from 1651 to date, five manuscript copies which circulated before Leonardo's art theory was printed, and a photographic archive of all such manuscript copies in European libraries and collections.

The Belt Library of Vinciana is supplemented by unpublished contemporary manuscripts on Leonardo, slides, photographs, records, and a microfilm archive. Much material bearing on technological history is included.

Dr. Belt, a Los Angeles urologist and a noted Vincian scholar, was awarded the Silver Star of Solidarity by the Italian government in 1952 in recognition of his studies of Leonardo and his efforts in preserving information and works about the noted Italian. The citizens of the Italian town of Vinci have made Dr. Belt an honorary citizen of Vinci in recognition of his donations to their Leonardo da Vinci Library. Recently he received the title of Calviere del Merito (Knight of the Order of Merits from the Italian Republic. Dr. Belt is a member of the Advisory Council of the Society for the History of Technology.

Mrs. Kate Steinitz, librarian of the Elmer Belt Library of Vinciana for the past 16 years, is the author of a bibliography of Leonardo's famous "Treatise on Painting" which has won the praise of Vincian scholars all over the world.

The Belt Library will be housed in a specially-constructed section of the UCLA Art Library in the projected new Art Building planned for completion in 1964.

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The International Secretariat for Research on the History of Agricultural Implements published a complete catalogue of its library in

August 1960 and will continue to publish annual lists of its accessions. The Secretariat is located in the National Museum, Copenhagen K., Denmark.

* * *

There will be a session on the History of Technology at the meeting of the Pacific Coast Branch of the American Historical Association, to be held at San Jose State College, August 29-31. Dr. John B. Rae will speak on "Science and Engineering in the History of Aviation" and Professor Robert S. Woodbury on "The Origin of Precision Gauge Blocks." Professor Gerry Wheeler, editor of the *Journal of the Aviation Historical Society*, will preside at this session, and Dr. John Niven of the Claremont Graduate School and Mr. Charles Perrine, Chief Engineer of Convair, will act as commentators.

* * *

Case Institute of Technology announces the establishment of an Archive of Contemporary Science and Technology.

National concern over the vanishing record of scientific activity and technological research and development of the past sixty to one hundred years has prompted Case Institute of Technology to establish this Archive where personal documents, research manuscripts and records, and other materials dealing with scientific and technological development will be housed, catalogued, and studied. It is expected that this Archive will provide a means of preserving materials of historic interest for scholars of the history of science and technology.

All persons, companies, and institutions are invited to send, to the Case Archive of Contemporary Science and Technology, such materials as they believe should be considered for inclusion in the Archive. These should be addressed to Dr. Robert E. Schofield, Curator, Archive of Contemporary Science and Technology, Case Institute of Technology, Cleveland 6, Ohio.

Monopoly on Wheels

Henry Ford and the Selden Automobile Patent

By William Greenleaf

"It is an ironical fact that the grant of a U. S. patent—a device originally designed to give impetus to the inventive talents of a people—all too frequently has the opposite result. Almost from the beginning the potentialities of the patent as a weapon of the large, powerful corporation against its smaller competitors were recognized and put to use.

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MONOPOLY ON WHEELS is the detailed narrative of a major turning point in the development of the automobile and in the career of Henry Ford. This is the first account of one of the epoch-making developments in American industry and technology.

The Selden patent was controlled by an alliance of Eastern financiers and established motor makers, who attempted to make it a legal monopoly. Their bold scheme might have succeeded had not Henry Ford determined to resist. The result was an epic trade war that lasted from 1903 to 1911.

Ford, with his conviction that the automobile must become a low-priced, mass-produced commodity for the people, found himself opposing a vested interest.

The Selden patent battle thus became a landmark in the social and technological revolution brought about by the automobile, a force which more than any other furnished the impetus behind the coming-of-age of industrial and urban America at the beginning of the century.

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